

Optically rewritten fall of a levitated diamond

FDT analysis

Target: Anshuman Nayak, Daehee Kim,
Shilu Tian and Jason Twamley,

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Abstract

Nayak et al. report that they demonstrate controllable centre-of-mass motion, due to force from an ensemble of nitrogen-vacancy defects in diamond, of a 128 mg diamagnetically levitated oscillator [1]. The measured displacement is converted to force through its mechanical response; the population model and its common normalization remain distinct from that measurement. Fundamental Density Theory (FDT) reads the resonator as one confined pattern whose light-written moment changes its energy across the magnetic density gradient. The wing reading and the helical energy window developed here are the author’s constructions. They recover the source’s force and oscillator equations on the same inputs. Five prospective predictions add physical input: three conditional existence tests of a field from static twist, and two conditional isotope tests of a density-coupled equilibrium response. Each compares neighbouring preparations, retains the conventional channels, and states detection, exclusion and attribution criteria. One separate exploratory observable reads the existing drive as a change in the slope of a clock factor.

1 Framework

The **source_status** is experimental [1]. Measured, observed and reported name source results, with estimated forces, simulated populations and in-sample model comparisons identified locally. Derived, estimated, reconstructed and illustrative-assumed name this analysis’s calculations. SC labels identify source claims and L labels their physical loci; U labels identify explicit non-source inputs. The physics clauses used here are those of the locked core v6.2 [2]. FDT is a true extension of general relativity and quantum mechanics. Its recovery of their data and its additional physical inputs are both operative below.

1.1 One medium, fixed rate and discrete patterns

Matter, energy and spacetime are forms of the omnium (0.1). Let E be energy, m rest mass, c the strand rate, d a distance and t a time. The metric is $g_{\mu\nu}$, with Greek indices labelling coordinates. The electromagnetic response coefficients are ε_0 and μ_0 ; h is Planck’s constant and $\hbar = h/(2\pi)$. For mode label q , ω_q , E_q , m_q , T_q and ℓ_q denote angular frequency, energy, rest mass, period and Compton length. Clauses 0.1a and 0.1d give the relations below. Upright unit symbols denote SI units: m metre, s second, kg kilogram, J joule, N newton, T tesla, K kelvin, Hz hertz, W watt and C coulomb; prefixes retain upright type.

$$\begin{aligned} E/m &= c^2 = 1/(\varepsilon_0\mu_0) = (d/t)^2, \\ E_q &= m_q c^2 = \hbar\omega_q, & T_q &= 2\pi/\omega_q = h/E_q, \\ \ell_q &= cT_q = h/(m_q c), & d/t &= c = 299792458 \text{ m s}^{-1}. \end{aligned} \tag{1}$$

The last value is exact (U-01). The massive equalities describe confined patterns. A stroke's period and path obey the same locked ratio without a rest-mass assignment. Quantized energy puts discreteness into confinement eigenvalues and null paths and periods; the chart over them is continuous. The existence bounds $2\ell_P$ and $2t_P$, with ℓ_P and t_P the Planck length and time, are one-sided infima, not a lattice. A Compton length never sets a support radius R_{box} .

Let v and u be the translational and internal strand rates of a closed pattern, and γ its boost factor. Its helix obeys $v^2 + u^2 = c^2$; its inertia E/c^2 includes the closure stress (von Laue, 0.1d). The open stroke runs straight at c and keeps no time. Its grades turn at angle $\pi/4$. For wavelength $\mathfrak{W}$, angular frequency ω and wavenumber k , their turn radius r_{turn} and the closed-mode dispersion are (I-2)

$$\begin{aligned} r_{\text{turn}} &= \hbar c/E = c/\omega = \mathfrak{W}/(2\pi), \\ \omega^2 &= c^2 k^2 + (mc^2/\hbar)^2, \quad (\omega/k)(d\omega/dk) = c^2. \end{aligned} \tag{2}$$

The phase rate exceeds the run for a closed pattern. Their equality belongs to the open stroke; their ratio is not the pitch of a closed phase helix. The response coefficients yield the one rate, and one medium at that rate has one carrier (I-2): photon = graviton = gluon = phonon = magnon. Closed electron and nuclear patterns are outside that identity.

For helix amplitude A , phase ϕ , initial phase ϕ_0 and mode projection ψ and imaginary unit i , cylindrical coordinates lift the mode into helical transport. Let ϕ_h denote its time phase, and let $\mathbf{e}_1, \mathbf{e}_2$ be orthogonal unit vectors with bivector $\mathbf{B} = \mathbf{e}_1 \mathbf{e}_2$ and $\mathbf{B}^2 = -1$. The transverse coordinates x_h, y_h and the single-angle phase rotor are

$$\begin{aligned} \psi &= A e^{i\phi_h}, \quad \phi_h(t) = \phi_0 - \omega t, \\ (x_h, y_h) &= (A \cos \phi_h, A \sin \phi_h), \quad e^{\mathbf{B}\phi_h} = \cos \phi_h + \mathbf{B} \sin \phi_h. \end{aligned} \tag{3}$$

The exponent is dimensionless, and this rotor differs from a half-angle spinor rotor. Initial-phase ignorance is I-4's superposition reading. Neither a curvature token nor a strand count is assigned to the oscillator mode.

1.2 Notation guard

The table defines the source quantities before their use. Its left column names source spellings, including their distinct senses; the right column fixes this manuscript's symbols. Cartesian subscripts select components. Core n is strand count, σ a branch tag, κ the Einstein coupling, X odds, D the confinement operator, Ω its domain, a the radiation constant, R a reserved length family. The core meanings of τ (proper time), χ (orientation), θ (ray angle), ξ (dimensionless confinement eigenvalue), ζ (shape constant), $\mathcal{J}$ (neighbour separation), $\mathfrak{m}$ (clock factor), $\mathfrak{s}$ (translation share), $\mathfrak{f}$ (strand-plane flip) and $\mathfrak{F}$ (allowed final-state family) are retained; unused symbols acquire no experimental meaning.

Source spelling	Definition and manuscript symbol
Gyromagnetic gamma	$\mathbf{g}_e$, frequency per magnetic field; γ remains boost factor.
Splitting glyph; duty D	$\mathfrak{D}$, zero-field splitting; η , illuminated fraction of a drive period.
B and components	$\mathcal{B}$, magnetic field; $\mathcal{B}_0$, bias value; $\mathcal{B}_x, \mathcal{B}_y, \mathcal{B}_z$, components.
Gradient b or Gz	$\mathcal{G}$, vertical magnetic gradient; G remains Newton’s constant.
Spin S and components	$\mathcal{S}$, dimensionless spin operator; $\mathcal{S}_x, \mathcal{S}_y, \mathcal{S}_z$ are components.
Displacement Sxx	$\mathfrak{S}_{xx}$, displacement power spectral density.
Moment m; mass m	$\mathbf{m}$, magnetic moment; $\mathbf{m}_z$, its vertical component; $\mathcal{M}$, resonator mass.
Spin projection ms	$\mathbf{m}_s$, upright state label, never a mass.
Bohr magneton	$\mathbf{m}_B$, moment unit (U-06).
Field angles theta, phi	α , NV-axis–field angle; $\mathbf{b}$, field azimuth about the NV axis.
Family angles	$\mathbf{p}_i, \mathbf{q}_i$, polar and azimuthal angles of family i .
Rotation R	$\mathfrak{R}_i = \mathfrak{R}_z(\mathbf{q}_i)\mathfrak{R}_y(\mathbf{p}_i)$, family-to-laboratory rotation.
Unitary U	$\mathfrak{U}$, eigenvector basis transformation; U remains pair energy.
Density matrices rho	$\mathfrak{r}_{th}, \mathfrak{r}_e, \mathfrak{r}_{NV}$, thermal, energy-basis and NV-basis matrices.
Force f	$\mathcal{F}_z$, force per source spin; $\mathcal{F}_{th}$, its thermal value.
Frequency f0	f_0 , drive and mechanical resonance frequency; $\omega_0 = 2\pi f_0$.
Amplitude A	$\mathcal{A}$, measured displacement amplitude; A retains its core mode meaning.
Integration widths	$\Delta\omega, \Delta f$, angular and cyclic frequency half-widths.
Intensity I; power	$\mathcal{I}$, light intensity; $\mathcal{P}$, peak optical power.
Quality factor Qm	$\mathcal{Q}$, motional quality factor; Q retains charge parity.
Gap d	$\mathbf{h}$, magnet–diamond separation; d retains pair distance.
Boltzmann kB	k_B , Boltzmann’s constant; k remains wavenumber.
Temperature T; times	T , temperature; $\mathfrak{T}_1$, relaxation time; $\mathfrak{T}_{osc}$, drive period.
Hamiltonian HNV	$\mathcal{H}_{NV}$, NV Hamiltonian; the article “a” in “a single” is no symbol.

The notation corresponds to the source equations and apparatus definitions cited with each use below. New names used below are defined with their observables. A bare α always denotes a curvature ratio; populations, duty, angles and moment fractions acquire no such token.

1.3 Force, charts and the two readings

Let F denote the pair force. For Newton constant G , universal force bound $F_{\max}$ and inputs α_1, α_2 , I-1 and I-6 state

$$F = F_{\max}\alpha_1\alpha_2, \quad F_{\max} = \frac{c^4}{4G}, \quad 0 < \alpha < 1, \quad F < F_{\max}. \quad (4)$$

This law holds at every scale. For nonoverlapping spherical supports of radii $R_{b,i}$, gravitational radii $R_{s,i}$ and masses $\mathcal{M}_i$, the static monopole pair domain is $R_{b,i} \geq R_{s,i}$ and $d \geq R_{b,1} + R_{b,2}$. At the other centre each input is $\alpha_i = R_{s,i}/d$. On that domain the algebra gives

$$F = \frac{c^4}{4G} \frac{2G\mathcal{M}_1}{c^2d} \frac{2G\mathcal{M}_2}{c^2d} = \frac{G\mathcal{M}_1\mathcal{M}_2}{d^2} \leq \frac{F_{\max}}{4}. \quad (5)$$

Equality in the domain bound is contact of saturated equal supports. The reduction is exact in FDT; its correspondence to the general-relativistic force expansion is leading weak-field, slow-motion order (I-4’s L2 layer). With linear mass densities $\lambda_i = \mathcal{M}_i/d$, the same expression is $G\lambda_1\lambda_2$. This algebra does not determine electromagnetic input values. The bare condensed-matter force scale quoted by I-1 is $\sim 10^{-41}$ N; a driven rate is a different observable.

The chart inventory below exhausts the curvature tokens used here. For a positive gravitational radius $R_s = 2G\mathcal{M}/c^2$ and a field-point radius r_f , the exterior atlas applies at $r_f > R_s$; the interior atlas applies at $r_c \leq r_f < R_s$, with r_c a finite core cutoff. Configuration and source are separate evaluations. For a bound configuration the interior room radius R_{room} comes from data, its skin lies at the fold, and no transfer map identifies its interior coordinate with its source exterior radius. Interior observations

are profile-weighted means over their actual observation regions. The computational coordinate is β_σ ; it is never a force input. The site diagnostic $\alpha_{\text{core}} \rightarrow 1^-$ is P-3's schematic nuclear skin saturation, distinct from carbon exterior compactness.

Application	Tokens	Warrant and use
A-1 compactness	$\alpha_\sigma, \alpha_{\text{ext}}, \alpha_{\text{int}}$	Geometric warrant; Earth, resonator and carbon source evaluations, tagged below.
A-2 atlas coordinate	β_σ	Geometric warrant; computational only, no observable assignment.
A-3 overlap contrast	α_{ovl}	PROVISIONAL: open range only; no value, threshold, ordering or sign.
A-4 confinement	α_{conf}	PROVISIONAL: open range only; no value or address.
A-5 mode	α_{mode}	PROVISIONAL: open range only; no value or trajectory.
P-3 skin diagnostic	α_{core}	Schematic limit only; no identification with an exterior source evaluation.

The branch label is $\sigma = +1$ outside and $\sigma = -1$ inside. The odds $X_{\text{ext}}, X_{\text{int}}$ and X have their geometric meaning; α_0 denotes a starting curvature value and x a nonnegative odds enhancement. I-3 and I-6 give

$$\begin{aligned}
\alpha_\sigma(r_f) &= (R_s/r_f)^\sigma, & \alpha &= X/(1+X), & X &= \alpha/(1-\alpha), \\
X_{\text{ext}} &= \frac{R_s}{r_f - R_s}, & X_{\text{int}} &= \frac{r_f}{R_s - r_f}, \\
\alpha(x) &= \frac{\alpha_0(1+x)}{1+\alpha_0x}.
\end{aligned} \tag{6}$$

The atlas ratios are already bounded by their domains; the odds identity does not compactify them again. Neither a range nor a fit establishes geometric warrant. On A-1's exterior branch the seam is $\alpha_{\text{ext}} = 1/2$ at $r_f = 2R_s$, distinct from the fold.

Let ds_{opt} denote optical distance, $d\mathcal{W}_{\text{ang}}^2$ the angular line element, $j_{\text{opt},1}, j_{\text{opt},2}$ the exact ray indices on two regions, and θ_1, θ_2 their ray angles. Let $g_{\mu\nu}$ be the spacetime metric, $G_{\mu\nu}$ its Einstein tensor, and $T_{\mu\nu}$ the stress tensor. I-3's other two faces are

$$\begin{aligned}
ds_{\text{opt}}^2 &= \frac{dr_f^2}{(1-\alpha_{\text{ext}})^2} + \frac{r_f^2 d\mathcal{W}_{\text{ang}}^2}{1-\alpha_{\text{ext}}}, \\
j_{\text{opt},1} \sin \theta_1 &= j_{\text{opt},2} \sin \theta_2, & G_{\mu\nu} &= \kappa T_{\mu\nu}, & \kappa &= 8\pi G/c^4.
\end{aligned} \tag{7}$$

The Einstein equation is unchanged, with curvature ratios downstream of its solution. The same source and data give the same curvature: I-3 containment. The aperture quantities c_{eff} and n_{cone} describe a distinct constitutive question.

Let $\mathcal{U}^\mu$ be a pattern's four-velocity and $\mathfrak{P}^{\mu\nu}$ its spatial projector. The clock factor $\mathfrak{m}$ rescales kept time and thread length together. Clause 0.1c gives

$$\begin{aligned}
g_{\mu\nu} &\longmapsto \mathfrak{m}^2 g_{\mu\nu}, & g_{\mu\nu} \mathcal{U}^\mu \mathcal{U}^\nu &= -c^2, \\
\mathfrak{P}^{\mu\nu} &= c^2 g^{\mu\nu} + \mathcal{U}^\mu \mathcal{U}^\nu, & \nabla_\mu \mathcal{U}^\mu &= -\mathfrak{P}^{\mu\nu} \partial_\nu \ln \mathfrak{m}.
\end{aligned} \tag{8}$$

Moving at constant speed, on the pattern's own clocks and rulers, through a density gradient is gravity. On the pattern's own clocks and rulers the crossed gradient registers nothing; neighbours or a reference path read it. A slow pattern reads the lapse $\sqrt{1-\alpha_{\text{ext}}}$, and a stroke reads the exact optical metric, including I-3's factor of two. A conformal clock factor bends no stroke. Domain declaration: in the medium window the stress tensor has perfect form. There the flow's clock factor is proportional to

temperature at zero net conserved count, and to enthalpy per count $(E + PV)/N$ at fixed entropy per conserved count N , with pressure P and volume V . This flow law includes its pressure force. The frequency of a clock carried by the medium follows that clock's own thermal motion, measured separately.

For the bookkeeper, a pattern released from rest far away has $v = c\sqrt{\alpha_{\text{ext}}}$ and radial acceleration $-GM/r_f^2$ exactly. A rotating source adds swirl; half its curl is the local frame drag, equal to the Lense–Thirring result at leading order. This is the antisymmetric gradient of the three-velocity on constant-own-time slices. The gravitational-window four-velocity is irrotational; the frame drag is not a medium's vorticity. The flow operates at laboratory sizes.

1.4 Confinement and channel accounting

Let u_q be a confinement eigenmode of a pattern confined to Ω , B its boundary data, $\mathfrak{t}$ its position on the inside/outside chart and χ its orientation. I-5's strand class n is distinct from its mass eigenvalue:

$$D(\Omega, B; n, \chi, \mathfrak{t})u_q = \omega_q u_q, \quad m_q c^2 = \hbar \omega_q. \quad (9)$$

The operator's status is O-9 in the status ledger. An electron is a closed $n = 3$ pattern. Same-count patterns acquire different masses through confinement; a change in count is rebraiding. These statements give neither a mass formula nor an absolute confinement address. Let M denote the rest-matter entry of the total gravitating mass, σ_{SB} the Stefan–Boltzmann constant and a the radiation constant. The I-7 accounting is

$$\mathcal{M} = M + E/c^2 + PV/c^2 + aT^4V/c^2 + \dots, \quad a = 4\sigma_{\text{SB}}/c. \quad (10)$$

Each physical channel enters once: an E that already includes radiation has no separate radiation entry. Binding belongs to the solved geometry. Isotope substitution at fixed evaluation radius raises compactness with carbon mass. Observable signs additionally require their channel sensitivities; finite shifts are path integrals, not local derivatives multiplied by an arbitrary span (I-7).

2 System chart

Earth's gravitational parameter and mean radius are illustrative-assumed reference inputs (U-07; IERS conventions [4]); G and the electron mass use CODATA values (U-03–U-04 [3]). The table below defines $\mathcal{M}_{\oplus}, R_{\oplus}, R_{\text{s},\oplus}$ and the source evaluations $\alpha_{\text{ext},\oplus}, \alpha_{\text{ext},\text{res}}, \alpha_{\text{ext},\text{C}}$; $\mathcal{M}_{\text{C}}$ is the carbon site's gravitating mass.

Quantity and chart	Input, evaluation or derived value
Earth source, A-1 exterior	$G\mathcal{M}_{\oplus} = 3.986004418 \times 10^{14} \text{ m}^3\text{s}^{-2}$; $R_{\oplus} = 6371.0 \text{ km}$ (U-07).
Earth gravitational radius	$R_{\text{s},\oplus} = 2G\mathcal{M}_{\oplus}/c^2 = 8.870 \text{ mm}$.
Earth at the resonator	$\alpha_{\text{ext},\oplus} = R_{\text{s},\oplus}/R_{\oplus} = 1.392 \times 10^{-9}$.
Resonator at Earth centre	$\alpha_{\text{ext},\text{res}} = 2G\mathcal{M}/(c^2 R_{\oplus}) = 2.98 \times 10^{-38}$, using $\mathcal{M} = 128 \text{ mg}$ (SC-020a, L81).
Laboratory flow	$v = c\sqrt{\alpha_{\text{ext},\oplus}} = 11.186 \text{ km s}^{-1}$.
Carbon site, A-1 exterior	$\alpha_{\text{ext},\text{C}} = 2G\mathcal{M}_{\text{C}}/(c^2 r_f)$; declared $r_f > R_{\text{s},\text{C}}$ held fixed through substitution.
Bound crystal interior	R_{room} is set by the slab geometry; every interior datum uses its observation profile.
Nuclear skin	$\alpha_{\text{core}} \rightarrow 1^-$, schematic P-3 diagnostic only.

Earth is below the A-1 exterior seam, in the general-relativistic regime. The resonator input is a correct small gravitational window. Its support and Earth's are nonoverlapping at monopole order; the weight from Eq. (5) is

$$F_{\text{max}} \alpha_{\text{ext},\oplus} \alpha_{\text{ext},\text{res}} = G\mathcal{M}_{\oplus} \mathcal{M} / R_{\oplus}^2 = 1.26 \text{ mN}. \quad (11)$$

The mass has three significant figures, which limit the weight and resonator input. The Earth entries use no more than the radius's five figures. No curvature ratio is attached to an ensemble fraction or duty.

3 Observation map

3.1 Apparatus and displacement

The reported slab is $3 \times 3 \times 0.5$ mm with 4.5 ppm NV, a slab-volume mean over centres the source calls uniformly distributed (SC-071a, L350), faces cut along [100], and four families at approximately 54.7° (SC-071c, L353; SC-071d, L354; SC-071e, L355). The angle is the reconstructed $\arctan \sqrt{2}$. A carbon-fibre rod of length 5 cm and diameter 0.5 mm joins it to a slotted $10 \times 10 \times 1$ mm graphite plate (SC-073b, L358; SC-074a, L362). Four N52 magnets in a checkerboard support the plate; their side is 12.7 mm, and a 4 mm iron plate shields the diamond (SC-074b, L363; SC-074c, L364; SC-074d, L366; SC-072a, L384). Slot removal and glue prevent computing the total mass from those solid dimensions. The source's measured apparatus inputs are

$$\mathcal{M} = 128 \text{ mg}, \quad f_0 = 17.6 \text{ Hz}, \quad \mathcal{Q} = 55. \quad (12)$$

These are SC-020a at L81, SC-020b at L82 and SC-020c at L86. The reported room temperature is $T = 300$ K, the chamber is at atmospheric pressure, and displacement is sampled at 2440 Hz (SC-078a, L398; SC-078b, L399; SC-078c, L400). The mirror on the graphite is compared with a fixed head above it (SC-020d, L87; SC-020e, L89; SC-087, L380). The head is the reference path of Use item 7, so the fall is read between mirror and head and never off the resonator's own clocks and rulers (0.1c); the reading is the record's displacement measurement, the identity map of Use item 2 at the noise in the source's measurements (SC-067a, L385), and corroborates no invariant; equal motion of head and mirror would remove this differential signal.

3.2 Spin model, sign and preparation

Let $\mathcal{S}_{\text{NV}}$ denote the spin component along the NV axis. The reconstructed source Hamiltonian and moment convention are

$$\mathcal{H}_{\text{NV}} = h\mathfrak{D}\mathcal{S}_{\text{NV}}^2 + h\mathfrak{g}_e\mathcal{B} \cdot \mathcal{S}, \quad \mathfrak{m} = -h\mathfrak{g}_e\langle \mathcal{S} \rangle. \quad (13)$$

The Hamiltonian is SC-019b, L78; the minus sign is SC-022a, L92. The splitting input is $\mathfrak{D} = 2.87$ GHz (SC-019c, L80), and $\mathfrak{g}_e = 28$ GHz T^{-1} (SC-019e, L82). The frequency convention needs h , not $\hbar$. The source also prints a positive moment sign in its thermal trace (SC-022b, L145). The negative sign in Eq. (13) is selected by its positive Zeeman Hamiltonian and its simulated attraction toward larger field magnitude (SC-079d, L138); the two source signs are not identical. Let Z be the partition sum over the three eigenenergies E_j . The source thermal model (SC-025b–SC-025c, L107) is

$$\mathfrak{r}_{\text{th}} = e^{-\mathcal{H}_{\text{NV}}/(k_{\text{B}}T)}/Z, \quad Z = \sum_{j=1}^3 e^{-E_j/(k_{\text{B}}T)}. \quad (14)$$

The source's basis transform uses a transpose (SC-038, L145). For complex orthonormal eigenvectors in the convention used here it is reconstructed with the adjoint $\mathfrak{U}^\dagger \mathfrak{r}_e \mathfrak{U}$. A real basis makes the two operations coincide; arbitrary complex rotations do not. Rotations between the four families and the laboratory remain separate from the local field's angles (SC-039a, L154). These reconstructions are identity maps of I-4's conventional limit and corroborate no invariant; a sign or basis inconsistency falsifies the reconstruction at algebraic precision.

P-3 calls nuclei "fixed pinning sites"; P-2 supplies the nodal and clamp geometry. The author's reading is a nitrogen clamp beside a missing clamp, with nodal modes set by that geometry. The

splitting and the reported 637 nm line (SC-077b, L395) are read as differences of confinement eigenvalues, as 0.1d reads material clocks. The optical pumping of the defect, the line, the splitting and the defect's return to the thermal state with the light off are same- n changes of confinement mode (excitation and eigenmode relaxation), each closure of the defect keeping its strand count, never a rebraiding (I-5). I-5 states, "There are no intrinsic particle masses or properties." The author's held moment is a configuration projection written by the light and erased by the lattice. In the author's reading, in the experiments of Stern and Gerlach (SC-006c, L31) the gradient sorted each atom by its circulation sense; here the NV centres are in a thermal spin state with a small magnetic moment (SC-084b, L132) before the light raises it, and the mechanical resonator with a total mass of 128 mg (SC-020a, L81) is moved by the gradient as one body. The source model's levels are a ground-state triplet, an excited-state triplet and a single intermediate state (SC-036b, L204; SC-036c, L205), and the source says that when the NV axis is aligned with the local $\mathcal{B}$ field, optical spin polarization pumps the population "predominantly" into $m_s = 0$ (SC-028d, L157; SC-029a, L158; SC-029b, L159). In the author's reading the preparation runs up through the excited triplet and returns through the intermediate state into the zero spin projection; in that reading the held moment, the settled pumped configuration, is the difference between the forward and return routes, and with the light off, the lattice settles the ensemble by a third route. The source says that after the laser is turned off the spins relax back to τ_{th} within the longitudinal NV spin relaxation time $\mathfrak{T}_1$ (SC-031a, L178; SC-031b, L179). In the author's reading the forward and return routes are distinct events, and their composition does not commute (0.1a); a collective settlement is many-to-many. The three-level ground sector, three-level excited sector and intermediate state give the source's seven-level rate model (SC-036a, L202). Its rates and detailed supplementary population histories are unprinted.

In the author's reading, mixed eigenstates are tilted windings between the NV axis held by $\mathfrak{D}$ and the field axis pulled by $\mathbf{g}_e \mathcal{B}$. The derived crossover scale is

$$\mathfrak{D}/\mathbf{g}_e = 0.10 \text{ T}. \quad (15)$$

The gyromagnetic input's two figures set this precision. The source says pumping is "predominantly" into the zero projection when aligned (SC-029a, L158; SC-029b, L159), and says the eigenstates become mixed off-axis in strong fields (SC-029d, L161; SC-029e, L162). The labelled nodal reading uses I-5 at the precision of these qualitative mode assignments; a splitting independent of all boundary and confinement changes would falsify that reading. The numerical scale above is an identity from source inputs and corroborates no invariant.

3.3 Driven force and the estimator

The source's force per spin is $\mathcal{F}_z = \mathbf{m} \cdot \partial_z \mathcal{B}$ (SC-021b, L90). Its volume integral (SC-024b, L97) requires a spin-density weight when $\mathcal{F}_z$ retains that per-spin meaning. Define n_{NV} as that number density and $F_{\text{GL}}, F_{\text{th}}$ as optical and thermal total forces. A dimensionally explicit reconstruction is

$$F = \int_V n_{\text{NV}} \mathbf{m} \cdot \partial_z \mathcal{B} dV, \quad \Delta F = F_{\text{GL}} - F_{\text{th}}. \quad (16)$$

The source takes equal shares of four families and a uniform moment over an approximately 1 mm spot at its centre value (SC-039b, L159; SC-039d, L161; SC-040b, L164; SC-040c, L165). Neither a resolved moment map nor a spin-density normalization measurement is printed. The field simulation uses a finite-cylinder expression (SC-035b, L196); the caption's 0.63 T, -98 T m^{-1} and $z = 1 \text{ mm}$ are simulated inputs (SC-079a, L136; SC-079b, L137). Its intensities are 0, 10, 30, 50 mW mm^{-2} (SC-079c, L137). The off-axis field obeys $\nabla \cdot \mathcal{B} = 0$ (0.1d), read here as circulation without free ends; a purely axial gradient over a finite spot requires transverse components. The source's lateral cancellation cites supplementary symmetry (SC-032, L184), leaving the finite-spot remainder unquantified. This profile

reading applies I-3’s observation-region rule; a resolved profile inconsistent with the assumed uniform average falsifies that average, at the spatial map’s measured precision.

Let χ_A be a causal, absolutely integrable response kernel. I-1’s observable rule is $A(t) = \int_{-\infty}^t \chi_A(t - t') F_{12}(t') dt'$, where F_{12} is the pair drive and bounded forcing makes the convolution converge. In this apparatus take the output to be $\mathcal{A}$ and define trap stiffness $\mathcal{K} = \mathcal{M}\omega_0^2$. The held moment is one of I-1’s listed driven observables (“induced magnetisation”). The source assumes pumping and relaxation fast against the drive period (SC-031c, L180). A rectangular force of height ΔF and duty η has fundamental $(2\Delta F/\pi) \sin(\pi\eta)$ and mean $\eta\Delta F$. The resonant response is $\mathcal{Q}/\mathcal{K}$, so its inverse is the source’s Eq. 2 (SC-058d, L307; SC-058e, L308; SC-058f, L309):

$$\mathcal{A} = \frac{\mathcal{Q}}{\mathcal{K}} \frac{2\Delta F}{\pi} \sin(\pi\eta), \quad \Delta F = \frac{\pi\mathcal{M}(2\pi f_0)^2}{2\mathcal{Q} \sin(\pi\eta)} \mathcal{A}. \quad (17)$$

The trace settings are $\mathcal{P} = 50 \text{ mW}$, $\eta = 48.73\%$ (SC-081a, L236) and estimated $\mathcal{A} \simeq 100 \text{ nm}$ (SC-042c, L186). The input precisions are respectively two, four and one significant figures; $\mathcal{Q}$ has two and $f_0, \mathcal{M}$ have three. The derived estimates are

$$\mathcal{K} = 1.57 \text{ N m}^{-1}, \quad \Delta F \simeq 4 \text{ nN}, \quad \eta\Delta F/\mathcal{K} \simeq 1 \text{ nm}. \quad (18)$$

The last quantity is the mean static shift, distinct from the resonant ring-up. All forces inferred this way are estimator identities; reproducing them corroborates no invariant. An independently applied calibrated force that misses Eq. (17) beyond the combined mass, damping, amplitude and duty uncertainty falsifies this response reconstruction.

The source’s PSD expression is an amplitude square integrated about the fundamental (SC-056e, L291; SC-056d, L292). Its peak versus rms convention is unstated; the estimate above uses its Eq. 2 with its trace amplitude. The normalized phase average covers 1200 s with a 56.8 ms window (SC-081b, L238); the latter is $1/f_0$ to the printed precision. Normalization discards the absolute amplitude. The source says the sinusoidal nature of the averaged motion “indicates” dynamics that “can still be well approximated” by a harmonic oscillator “with negligible nonlinearities” (SC-043e, L196; SC-044a, L197; SC-044b, L198; SC-044c, L199), without a printed nonlinearity bound. Its observation toward the magnet when light is on is “indicative” of attraction (SC-045a, L200; SC-045b, L201). At resonance displacement phase and the force sign require their transfer function; the schematic static shift (SC-084d, L134) is a different observable. These are I-4 identity comparisons at the source’s trace precision, not independent corroborations; at resonance a displacement fundamental whose phase departs from quadrature with the rectangular force’s fundamental by more than the largest lag shift that the printed precisions of the averaging window, the resonance frequency and the quality factor allow, plus twice the phase’s standard error, falsifies this linear-response reconstruction.

3.4 Controls, calibration and energy channels

The source reports disappearance of the strong resonance peak when the magnet is removed at 10 mW and under 980 nm light at 50 mW (SC-049a, L254; SC-049b, L256; SC-049c, L257; SC-050a, L258; SC-052a, L248). Magnet removal removes both the population bias and the gradient (SC-080a, L239; SC-080b, L240). The source also reports small residual chopper excitation with the laser off (SC-048b, L247; SC-048c, L248), while its green modulation is electronic and shows no sympathetic modulation with that laser off (SC-048e, L250; SC-048f, L251). The caption states that the chopper was kept on for all measurements (SC-080d, L243). Absorbed-power matching is unprinted, so these controls retain distinct heat and momentum channels. The source says these results “demonstrate that the driving force is magnetic and depends on the spin polarization of the NV centers, confirming that the mechanical motion is mediated by the spin, rather than by thermal effects or optical artifacts” (SC-052a, L248; SC-052b, L249; SC-052c, L250; SC-052d, L251); the measured spectra are accepted with

those control settings. Its comparison is an identity limit of I-4; a matched-heating, NV-free control with the same signal would falsify the exclusive spin attribution at the measured force uncertainty.

The rate-model force is divided by 1.2, “consistent for all our measurements” (SC-037b, L174). Model curves compared with their calibration points are in-sample (SC-059b, L314; SC-059c, L315). The source reports rising force approaching saturation with power (SC-059d, L316; SC-059e, L317), and a maximum versus gap for both magnets (SC-063a, L294). Its explanation multiplies a falling gradient by a moment that rises then saturates (SC-063e, L297; SC-063b, L298; SC-063c, L305; SC-063f, L306). The gap scan lowers the cylinder with the spot fixed, in 1 mm steps; the initial gap and the maximum’s gap are unprinted (SC-083a, L361; SC-083b, L363; SC-060, L273). The second cylinder has twice the diameter and “similar magnetizations” (SC-061a, L279; SC-061b, L280). The inferred first-magnet force is stronger “even in the region where the latter produces a larger magnetic field” (SC-062a, L285; SC-062b, L287; SC-062c, L288). The source says this “supports” gradient coupling (SC-062c, L288; SC-062d, L291). This is consistent with the force product while the field, moment and gradient still covary. The source’s “direct measurement” wording (SC-064a, L318) refers to the Eq. 2 inference (SC-058a, L298): “forces reaching over 5 nN” (SC-065b, L322), with simulated gradients 10 to 100 T m⁻¹ (SC-065a, L321; SC-035b, L196). Neither fit recovery nor its scale factor corroborates an invariant; a held-out field-and-moment map inconsistent with the force product would falsify that reconstruction with its full covariance.

Define the diamond density ρ_d and specific heat c_d . Illustrative-assumed U-08 values are $\rho_d = 3.515 \text{ g cm}^{-3}$ and $c_d = 0.509 \text{ J g}^{-1} \text{ K}^{-1}$ at 300 K (SC-078a, L398). The source’s estimated rise is $\Delta T \simeq 3 \text{ K}$: the laser irradiation “can elevate the diamond’s bulk temperature” by that amount, referring to supplementary material (SC-046c, L206; SC-046d, L207). With the reported slab volume, let $\Delta E_{\text{heat}} = \rho_d V c_d \Delta T$. Let $\Delta \mathcal{M} = \Delta E_{\text{heat}}/c^2$ and $\Delta F_{\text{weight}} = G \mathcal{M}_{\oplus} \Delta \mathcal{M}/R_{\oplus}^2$. The one-figure estimates, using U-05 for radiation, are

$$\begin{aligned} \Delta E_{\text{heat}} &\simeq 2 \times 10^{-2} \text{ J}, & \Delta \mathcal{M} &\simeq 3 \times 10^{-19} \text{ kg}, \\ \Delta F_{\text{weight}} &\simeq 3 \times 10^{-18} \text{ N}, & aV[(T + \Delta T)^4 - T^4] &\simeq 1 \times 10^{-15} \text{ J}. \end{aligned} \tag{19}$$

The radiation estimate illustrates a resolved channel; it is not added a second time to a calorimetric energy that already contains it. The light momentum flux is $\mathcal{P}/c$ (I-2), giving 0.17 nN at 50 mW and 0.033 nN at 10 mW, with the powers’ two figures (SC-042b, L180; SC-049a, L254). The first is about one thirtieth of the force switched by the light; the source prints no beam direction through the slab (SC-040b, L164). These I-7 bookkeeping estimates predict a much smaller heat-weight signal than the Eq. 2 force; a measured heat-weight increment inconsistent with $\Delta E/c^2$ after all other channels are closed falsifies this I-7 reading at the calorimetric and force uncertainty. The source’s laboratory noise is about 1 nm (SC-067a, L385), not the quoted picometre sensor capability (SC-067c, L388). The sensitivity gain of three orders and a quality factor of order 10^5 with motion of order 100 μm are outlooks, not achieved runs (SC-067b, L387; SC-069c, L399; SC-069d, L400). The positive quality-factor exponent follows from the stated enhancement; its locus alone leaves the flattened exponent’s sign ambiguous.

4 Cone-position translation

P-5 states, “A magnetic field is a macroscopic helical density gradient of the omnium,” with “the bivector grade of the density field coherently aligned along an axis.” Its mechanical and magnetic projections share a density-gradient topography. The author’s reading is: “We imagine the laser pulses make the diamond act like an airplane wing — it is all about density differentials.” A wing and this diamond are bodies across a differential read through Eq. (8). Around the wing, the air’s patterns follow the medium window’s enthalpy-per-count law; the pressure differential left across the wing is its lift. The diamond itself follows the helical window constructed next. These are two applications of one

law, with different constitutive energies.

The author's terms are defined here: twist means the magnetic density geometry; held moment means the settled pumped configuration; flap means the 532 nm pulse train (SC-028a, L152); angle of attack means α ; lift means ΔF . Let z be vertical position, $\dot{z}$ and $\ddot{z}$ its velocity and acceleration, E_0 a constant reference energy, E_{lev} the plate and slab diamagnetic energy, and $\mathfrak{A}$ the pattern action. The author's construction is

$$\begin{aligned} E(z, t) &= E_0 + E_{\text{lev}}(z, t) - \sum \mathfrak{m}(t) \cdot \mathcal{B}(z, t), \\ \mathcal{M} &= E/c^2, \quad \mathfrak{m} = E/E_0, \quad \mathfrak{A} = - \int E d\tau. \end{aligned} \tag{20}$$

A spatially uniform heat input adds an energy level, counted once. Positive E makes this action the geodesic action of $\mathfrak{m}^2 g$. In a local one-dimensional inertial chart its Lagrangian is $-E(z, t) \sqrt{1 - \dot{z}^2/c^2}$; differentiating its momentum $E\gamma\dot{z}/c^2$ and applying the Euler–Lagrange equation gives

$$\ddot{z} = -(1 - \dot{z}^2/c^2) (c^2 \partial_z \ln \mathfrak{m} + \dot{z} \partial_t \ln \mathfrak{m}). \tag{21}$$

The time term vanishes for a static energy profile. Multiplying by Earth's lapse, taking the slow limit and holding the moment at its settled value gives, beside the air drag,

$$\mathcal{M}\ddot{z} = -G\mathcal{M}_{\oplus}\mathcal{M}/R_{\oplus}^2 - \partial_z E_{\text{lev}} + \sum \mathfrak{m} \cdot \partial_z \mathcal{B}. \tag{22}$$

The last term is Eq. (16); this derivation is the identity map on the source dictionary. The magnetic input map to I-1 is distinct from this energy identity. In the author's reading, a circulating configuration supplies that electromagnetic input; no magnetic force number here is obtained by assigning a gravitational compactness to its moment.

The energy level carries no push: a uniform additive heat level leaves $-\partial_z E$ unchanged, while changing inertia. The first spatial variation gives the push; the second gives the spring. A uniform field turns a held moment through its orientation-dependent energy but produces no translation in a uniform profile. An aligned held moment lowers energy where the field is stronger, and falls toward that region. The induced diamagnetic energy rises there, so the graphite is pushed upward. This sign follows the energy, not P-4's flow rule. In the author's reading the push on the diamond's held moment is the settlement between diamond and magnet, a step that 0.1a makes system-wide and many-to-many. The source's ignored diamond diamagnetism (SC-033a, L185; SC-033c, L187) remains in E_{lev} . The interferometer compares the mirror against its fixed reference path; the resonator's own rulers register no crossed gradient. Light-on minus light-off cancels weight, static levitation, static slab diamagnetism and static trap stiffness. Heat modulation, stiffness changes, light momentum and gas forces survive. Corroboration of this author's application of 0.1c and I-7 requires the measured energy gradient to predict an independently measured force at their combined precision; the source estimator identity itself corroborates no invariant.

5 Predictions

The following five blocks resolve different missing physical inputs. P-5 supplies a field from physical twist; I-7 supplies the isotope density route. A chart relabelling supplies neither. All five are conditional by construction. Each uses neighbouring preparations and a conventional comparator, and each specifies what a finite null excludes.

5.1 Common definitions and controls for twist

P-5 states, "Imposing a physical twist (torsion, helical geometry) on a material is establishing a magnetic field." The author's additional reading is that this field lies along the twist axis and reverses

with its hand. No quantitative twist kernel is declared. Let $\mathfrak{h} = \pm 1$ label hand and $\mathfrak{u} = \pm 1$ label bias orientation (U-13). For any one specified measured observable $\mathfrak{o}$, define its double-odd component $\mathcal{Y}$, the zero-twist coil slope $\mathfrak{B}$, and equivalent twist field $\mathcal{B}_{\text{tw}}$ by

$$\mathcal{Y} = \frac{1}{4} \sum_{\mathfrak{h}, \mathfrak{u}} \mathfrak{h} \mathfrak{u} \mathfrak{o}(\mathfrak{h}, \mathfrak{u}), \quad \mathcal{B}_{\text{tw}} = \mathcal{Y} / \mathfrak{B}. \quad (23)$$

The slope is measured with a known uniform coil-field step at zero twist, using the same measured line or force; it is not taken from the FDT input. A zero slope makes that setting uninformative and requires another bias. In the standard calculation static torsion is time-reversal even; it adds no magnetic field. The conventional force is bias-even because moment and gradient reverse together, and a strain-induced resonance shift is bias-even. Thus the ideal conventional double-odd component is zero. A vertical mirror of the cubic crystal containing [001] maps the hands and reverses the axial magnetic field. This removes only a perfect pair's terms odd in one reversal. An imperfect pair's mass, alignment, gap and offset are time-reversal even and still cancel if the whole field reverses.

The actual bias reversal leaves Earth's and laboratory fields, remanence, cylinder imperfections, shield and checkerboard residuals. With strain, rotation, shape or mismatch they generate double-odd terms. Remanence carried by one piece supplies one already at zero order. Microwave ellipticity in the torsion experiment and light travel direction in all three are further time-reversal-odd inputs. Null the uniform field at the spot once with the twist released, retain that coil setting for both hands, then step a known coil field at each hand. Carry the measured nuisance slope times the nulled residual, including both errors and their covariance. For rods and blades also step with gradient coils and carry the gradient slope times the nonreversing gradient: half the sum of field maps in the two cylinder orientations. For the slab also step microwave ellipticity and carry its slope times the residual ellipticity. The iron shield's reported thickness alone fixes none of those residuals (SC-072a, L384).

Alternate illumination through opposite faces at fixed spot, power and polarisation. For rods and blades repeat with the piece and beam rotated 90° about the vertical (U-13), reversing the checkerboard quadrupole against the piece's twofold shape. The statistical unit spans all these alternations; individual images or pulses are not independent units. The sign accounting is as follows; "survives" means a bounded nuisance unless a calibrated residual has been removed.

Channel	Double-odd and alternation response
Author's axial twist field	Odd in hand and bias; survives opposite-face illumination.
Conventional strain or matched static geometry	Bias-even; cancels in the double-odd mean.
Nonreversing uniform field times hand response	Survives; coil-step slope and residual set its correction.
Nonreversing gradient times shape	Survives; gradient step and piece rotation bound it.
Microwave ellipticity times torsion	Survives; ellipticity step bounds it for the slab.
Light momentum and directional heating	Travel-odd part cancels with face reversal; residual errors enter covariance.
Carried remanence	Survives before demagnetisation; test after release and demagnetisation.

Define $\mathcal{Y}_j^{\text{corr}}$ as a complete unit's double-odd result after nuisance corrections, $\bar{\mathcal{Y}}$ its unit mean, and $\mathfrak{d}$ that mean's combined standard uncertainty. With covariance matrix $\mathbf{C}$ of measured inputs and sensitivity vector $\mathbf{J}$ (Jacobian, distinct from the core's $\mathcal{J}$), $\mathfrak{d}^2 = \mathbf{J} \mathbf{C} \mathbf{J}^T$. Every slope, residual, temperature correction and alternation covariance enters this propagation. For independent variance components $\mathfrak{v}_j$ with degrees of freedom $\mathcal{R}_j$, the effective degrees of freedom $\mathcal{R}$ and the Student quantile $\mathfrak{z}$ are used below. The function $\mathfrak{t}_{p, \mathcal{R}}$ denotes the Student quantile at probability p . They obey

$$\mathcal{R} = \frac{(\sum_j \mathfrak{v}_j)^2}{\sum_j \mathfrak{v}_j^2 / \mathcal{R}_j}, \quad \mathfrak{z} = \mathfrak{t}_{0.975, \mathcal{R}}. \quad (24)$$

The choice is two-sided size 0.05 (U-15). Correlated inputs are first propagated jointly into their independent experimental variance components.

Detection requires $|\bar{\mathcal{Y}}| > \mathfrak{z}\mathfrak{d}$ after all bounded contributions and their standard errors have entered the corrected mean and uncertainty. To state exclusion define a proposed field magnitude $\mathcal{B}_*$ (U-13) and the calibration error $\mathfrak{d}_b$ of $\mathfrak{B}$. For $\mathcal{D}_* = |\mathcal{B}_*\mathfrak{B}| - |\bar{\mathcal{Y}}|$, propagate its covariance to $\mathfrak{d}_*^2 = \mathfrak{d}^2 + \mathcal{B}_*^2\mathfrak{d}_b^2 - 2\text{Cov}(|\bar{\mathcal{Y}}|, |\mathcal{B}_*\mathfrak{B}|)$. Either sign of that field is excluded when $\mathcal{D}_* > \mathfrak{z}\mathfrak{d}_*$, using its own effective degrees of freedom. The finite null excludes these magnitudes; it sets no lower magnitude for an amplitude-free existence statement. Attribution requires the same sign at a second twist magnitude. Rod and blade attribution additionally requires disappearance on release and redetection at that sign after every piece is demagnetised in a decaying alternating field peaking above the N52 coercivity (SC-074b, L363; SC-078d, L401). Its numerical value is not specified (U-13). Survival of the twist field after this demagnetisation is the author's reading. Lower-coercivity carried remanence is erased by this operation.

The existence indicator is $\mathfrak{e}$ (U-16): presence has value one and absence zero. Its defining discrimination threshold is one; the physical detection threshold remains $\mathfrak{z}\mathfrak{d}$ for the named observable. The declared statistical calibration (U-16) uses 20 complete alternating units, Gaussian unit scatter of 1 in normalized units, 100000 trials per test and seed 20261025. This is an illustrative noise model, not a field sensitivity. Independent complete units give $\mathcal{R} = 19$ and $\mathfrak{z} = 2.093$; correlations within each unit are retained before its mean is formed. The simulations below apply each block's rule to its corrected complete-unit statistic at the comparator.

5.2 T-1: torsion of the NV slab

DC-1 discriminates SA-70: the specified crystal geometry alone leaves a static-torsion field untested. The additional source is P-5's physical twist, with the author's axial, hand-odd field reading. Use a slab of the reported crystal, $3 \times 3 \times 0.5$ mm with 4.5 ppm NV, a slab-volume mean over centres the source calls uniformly distributed (SC-071a, L350), and [100] faces (SC-071c, L353; SC-071d, L354; SC-071e, L355). Grip its two ends along [001] in a torsion stage. Apply equal opposite static elastic torsions, release them, and set a second magnitude (U-13). Read the lower optically detected magnetic-resonance line at the slab centre under 532 nm light (SC-028a, L152), with a reversed few-mT coil bias along [001] (U-13).

Here $\mathfrak{o}$ is that independently fitted line centre. Its Zeeman slope is measured by the zero-twist coil step; Eq. (23) solves the defining condition for $\mathcal{B}_{\text{tw}}$. The conventional comparator is zero after the listed nuisance corrections: static torsion and its strain are bias-even. The author's field supplies the missing hand-odd axial contribution. In the existence comparison,

$$\mathfrak{e}_{\text{FDT}} = 1, \quad \mathfrak{e}_{\text{conv}} = 0, \quad |\mathfrak{e}_{\text{FDT}} - \mathfrak{e}_{\text{conv}}| \geq 1. \quad (25)$$

This is conditional by construction, with no assigned field magnitude. Its neighbours are the two hands under both biases, cancelling all terms even under either reversal. Use hands $+, -, -, +$ with bias reversed within each. One unit contains a cycle at each light direction. The uniform-field null, hand-resolved coil steps, ellipticity steps and opposite-face illumination specified above are part of every unit.

Release the slab at each stage hand to bound the stage's own hand-correlated field. Measure the line's slopes against slab tilt and rotation, and against temperature at each setting. Bound microwave power and bias-polarized paramagnetic nitrogen. Propagate these with the field and ellipticity residuals in $\mathfrak{d}$, including their standard errors and shared calibration covariance. Detection is $|\bar{\mathcal{Y}}| > \mathfrak{z}\mathfrak{d}$; exclusion uses $\mathcal{D}_* > \mathfrak{z}\mathfrak{d}_*$ for the proposed field at either sign, and attribution requires the same sign at the second torsion magnitude and the released-stage bound. Thus a finite null rejects the specified field magnitude when that inequality holds. The seeded complete-cycle simulation gives comparator false rejection 0.049

for this two-sided rule (U-16), against nominal 0.05 (U-15). The P-5 contribution disappears in the conventional ablation; its existence indicator difference reaches the unit discrimination threshold.

5.3 T-2: the helical support rod

DC-2 discriminates SA-72: the reported support dimensions leave a hand-dependent field from a helical support untested. P-5 supplies the additional source. The author's reading is that the rod's helical field reaches the defects below its end. Rebuild the reported resonator with opposite-hand carbon-fibre rods, each 5 cm long and 0.5 mm in diameter (SC-073b, L358), wound at equal angles and matched in mass. A straight rod of those same dimensions and mass replaces each hand as the released control; a second equal-angle pair supplies the second magnitude (U-13).

Use 50 mW and 48.73% duty (SC-081a, L236) at gap $h = 0.5$ mm (SC-055, L267). Turn the bias cylinder over between runs at the same gap and lateral offset. Here $\mathfrak{o} = \Delta F$ is independently inferred for every run from Eq. (17), using that run's measured $\mathcal{M}$, $\mathcal{Q}$, f_0 and amplitude, not a fixed transfer function. Apply the zero-twist uniform-coil step to this same force observable to determine $\mathfrak{B}$ and solve Eq. (23). The ideal standard spin force is bias-even, and the helical shape is static, giving conventional zero. The additional axial field gives the conditional existence comparison

$$\mathfrak{e}_{\text{FDT}} = 1, \quad \mathfrak{e}_{\text{conv}} = 0, \quad |\mathfrak{e}_{\text{FDT}} - \mathfrak{e}_{\text{conv}}| \geq 1. \quad (26)$$

This prediction is conditional by construction, without a quantitative rod-to-defect field kernel. The two hand/bias neighbours cancel the static response even in either reversal.

Use four-run hand/bias cycles. A complete unit includes both opposite-face light directions and both piece-and-beam orientations separated by 90° (U-13). Null the uniform residual once with the straight rod, hold its coil setting, step uniform field at each hand, and step the nonreversing gradient with gradient coils. The half-sum of maps at the spot in the two cylinder orientations supplies that gradient residual. Carry both measured slopes times their residuals, with errors and covariance, inside $\mathfrak{d}$. Include remount scatter, gap and offset after every turn-over, per-run optical power and spot, and the chopper residual (SC-048b, L247; SC-048c, L248).

Detection is $|\bar{\mathcal{Y}}| > \mathfrak{z}\mathfrak{d}$ and exclusion at either proposed field sign is $\mathcal{D}_* > \mathfrak{z}\mathfrak{d}_*$, including slope error and shared calibration covariance. Attribution requires the same sign for the second helical angle, disappearance with each straight replacement, and redetection at that sign after every piece's decaying-AC demagnetisation above N52 coercivity. The author's reading is that the geometric twist field survives that operation. The seeded complete-unit simulation returns false rejection 0.050 at the comparator (U-16), against nominal 0.05 (U-15). A finite null excludes only the field magnitudes meeting the exclusion inequality; the P-5 existence contribution has unit difference on ablation.

5.4 T-3: a bonded diamond blade

DC-3 discriminates SA-69: the slab orientation leaves a handed bonded configuration untested. P-5 provides helical geometry as an additional source. The author's reading identifies a bonded relative rotation with that geometry. Cut two half-slabs at mid-height from one crystal of the reported kind (SC-070b, L418; SC-070c, L346; SC-071c, L353), stack them vertically along [001], and bond them at equal opposite rotations about [001]. A blade bonded at zero rotation replaces each hand as the released control, and a second pair has a second rotation (U-13).

Hang each blade from the reported rod, with 50 mW, 48.73% duty (SC-081a, L236) and $h = 0.5$ mm (SC-055, L267). Turn the cylinder over at fixed gap and offset. The observable $\mathfrak{o} = \Delta F$ uses each run's measured $\mathcal{M}$, $\mathcal{Q}$, f_0 and amplitude in Eq. (17). The zero-rotation uniform-coil slope independently converts its double-odd component to $\mathcal{B}_{\text{tw}}$. The conventional calculation is zero for the static shape with all fields reversed, whereas the author's hand-odd field survives the two-neighbour comparison:

$$\mathfrak{e}_{\text{FDT}} = 1, \quad \mathfrak{e}_{\text{conv}} = 0, \quad |\mathfrak{e}_{\text{FDT}} - \mathfrak{e}_{\text{conv}}| \geq 1. \quad (27)$$

This is conditional by construction; the bond-to-field kernel has no assigned magnitude. Static terms even in either hand or bias cancel.

Use four-run hand/bias cycles, each complete unit including opposite-face illumination and the piece plus beam turned 90° (U-13). With the zero-rotation blade, null the uniform field once and hold the coils across hands. Make known uniform-field steps at each hand and known gradient steps. Use the half-sum of the two cylinder maps for the nonreversing gradient. Their measured slopes times residuals, with all errors and covariance, enter $\mathfrak{d}$. Include remount scatter, gap and offset after turning the cylinder, per-run power and spot, and chopper excitation (SC-048b, L247). Additionally map the spot on each half relative to the cylinder axis and measure the bond layer thickness for every blade. Opposite illumination and the quadrupole reversal remain essential because these shape changes couple to nonreversing fields and light travel.

Detection uses $|\tilde{\mathcal{Y}}| > \mathfrak{z}\mathfrak{d}$. Exclusion at either proposed sign uses $\mathcal{D}_* > \mathfrak{z}\mathfrak{d}_*$, including the field-times-slope error. Attribution requires the same sign at the second rotation, disappearance in each zero-rotation replacement, and redetection at that sign after every piece's decaying-AC demagnetisation above N52 coercivity. Survival is the author's geometric-field reading. The seeded complete-unit simulation gives false rejection 0.049 at conventional zero (U-16), against nominal 0.05 (U-15). The finite exclusion scale and the unit existence difference are distinct: the former tests field magnitudes, the latter identifies the additional P-5 source removed in the conventional ablation.

5.5 Common isotope definitions

The two isotope tests use the author's reading of I-7's purely density-coupled equilibrium response. Define $\mathfrak{l}$ as lattice constant and $\mathfrak{w}$ as zero-point mean-square displacement. For an observable $\mathfrak{o}$, let $S_{\mathcal{M}}, S_{\text{lat}}, S_{\text{zp}}$ be its logarithmic derivatives with respect to carbon-site mass, lattice constant and $\mathfrak{w}$, each holding the other two fixed. Let $\mathfrak{V}$ be the full conventional-shift bound. Along substitution at a fixed exterior evaluation radius, I-7 and the A-1 chart give

$$\Delta \ln \alpha_{\text{ext},C} = \Delta \ln \mathcal{M}_C, \quad \Delta \ln \mathfrak{o} = \int (S_{\mathcal{M}} d \ln \mathcal{M}_C + S_{\text{lat}} d \ln \mathfrak{l} + S_{\text{zp}} d \ln \mathfrak{w}). \quad (28)$$

The lattice change is a separate geometric channel. The conventional calculation keeps the last two terms and takes $S_{\mathcal{M}} = 0$; it does not identify this exterior compactness with the nuclear skin. For the investigator-chosen test point $S_{\mathcal{M}} = 1$ all along the path (U-12), the density term is the finite log-mass ratio. The isotope masses are 12 u exactly and 13.003354835 u (U-10; AME2020 [5]); the common atomic mass unit cancels. Define $\mathfrak{L}_C$ as this log ratio and $\mathfrak{M}_C$ as the fractional mass change:

$$\mathfrak{L}_C = \ln(13.003354835/12) = 0.0803, \quad \mathfrak{M}_C = 13.003354835/12 - 1 = 0.0836. \quad (29)$$

The finite fractional and logarithmic shifts are distinct. The illustrative conventional bound is $\mathfrak{V} = 0.01$ in absolute log shift (U-11). The illustrative lattice contraction is -1.5×10^{-4} and the zero-point mean-square amplitude scales as mass to $-1/2$, each giving channels of order 10^{-3} for the assumed response (U-11). These are chosen bounds and channel sizes, not measurements in the source.

Co-varying channel	Input sign, heavy minus light	Observable contribution
Mass at fixed geometry	Positive	Positive at $S_{\mathcal{M}} = 1$; zero in comparator.
Lattice constant	Negative in U-11	Sign is that of $S_{\text{lat}} d \ln \mathfrak{l}$; included in bound.
Zero-point amplitude	Negative	Sign is that of $S_{\text{zp}} d \ln \mathfrak{w}$; included in bound.
Temperature, strain, volume and nitrogen	Measured per plate	Corrected with slopes; residual covariance retained.

Grow three heavy and three light plates from enriched methane in the same campaign, and three from the methanes mixed to about half heavy carbon (U-09). The assay determines each group's mean carbon mass. Plates, not repeated spectra or positions, are the independent units. Let $\bar{\mathcal{L}}_H, \bar{\mathcal{L}}_L, \bar{\mathcal{L}}_M$ be corrected group means of log observable, with H, L and M denoting heavy, light and mixed. Write $\mathcal{D}_{HL} = \bar{\mathcal{L}}_H - \bar{\mathcal{L}}_L$, with standard uncertainty $\mathfrak{d}_{HL}$ from the full covariance, including the conventional bound's error. For independent equal plate scatter $\mathfrak{s}_{\text{plate}}$ and three plates per group, $\mathfrak{d}_{HL} = \sqrt{2/3}\mathfrak{s}_{\text{plate}}$. The U-09 numerical example absorbs each plate's temperature and volume correction errors into its scatter; they are not added again. Its chosen conventional envelope is fixed. An experimentally estimated envelope has its standard error added once, with covariance.

Detection requires $|\mathcal{D}_{HL}| > \mathfrak{V} + \mathfrak{z}\mathfrak{d}_{HL}$. For the positive density test point, exclusion requires that the confidence interval for $\mathcal{D}_{HL}$ be disjoint from $[S_{\mathcal{M}}\mathfrak{L}_C - \mathfrak{V}, S_{\mathcal{M}}\mathfrak{L}_C + \mathfrak{V}]$, including assay, sensitivity and bound errors if estimated. For attribution define the assayed log-mass ratio fraction $\mathfrak{C}$ and residual $\mathcal{E}_{\text{mix}} = (\bar{\mathcal{L}}_M - \bar{\mathcal{L}}_L) - \mathfrak{C}\mathcal{D}_{HL}$. Propagate both shared light-group covariance and assay errors in $\mathfrak{d}_{\text{mix}}$. Attribution requires $|\mathcal{E}_{\text{mix}}| \leq t_{0.975,2}\mathfrak{d}_{\text{mix}}$ and a detected heavy-minus-light effect. The quantile for this attribution comparison is 4.303 (U-15).

5.6 T-4: isotope dependence of the zero-field splitting

DC-4 discriminates SA-84: the adopted splitting input leaves its density response unmeasured. The additional constitutive input is the author's I-7 equilibrium density channel. Grow the heavy, light and mixed plate sets just specified, each carrying the source's 4.5 ppm NV (SC-071d, L354). Measure zero-field magnetic resonance at the stated 300 K reference temperature (SC-078a, L398), measuring the residual field. Fit every plate's bare $\mathfrak{D}$ with Eq. (13) plus its first-shell hyperfine terms. This fitted splitting is independent of the mass assay that supplies the comparator input. For this observable the defining condition and solution are

$$\Delta \ln \mathfrak{D} = \int (S_{\mathcal{M}} d \ln \mathcal{M}_C + S_{\text{lat}} d \ln \mathfrak{l} + S_{\text{zp}} d \ln \mathfrak{w}). \quad (30)$$

Each sensitivity holds the other two variables fixed. It integrates the density sensitivity over the measured mass path; a local derivative alone is not its amplitude.

Let $\mathbf{A}$ be the first-shell carbon hyperfine tensor in frequency units, $\mathfrak{l}$ the nuclear spin, and $\mathfrak{E}_{\text{hf}}$ the axis angle to the NV axis. The illustrative-assumed inputs are $A_{\parallel} = 199.7$ MHz, $A_{\perp} = 120.3$ MHz and $\mathfrak{E}_{\text{hf}} = 106.8^\circ$ (U-14 [6]). The added Hamiltonian is $\hbar \sum \mathcal{S} \cdot \mathbf{A} \cdot \mathfrak{l}$. In the NV frame, A_x, A_y denote the tensor rows; their squared norms determine the transverse contraction. For the assumed unpolarized spin-1/2 nucleus (U-14), the transverse spin trace gives the ground-manifold shift $-\text{tr}(A_x^2 + A_y^2)/(4\mathfrak{D})$; the upper-manifold centroid shift is half its opposite. The trace notation means those squared Euclidean norms. For three first-shell nuclei define the fractional centroid correction $\mathfrak{H}$. To second order, using the source's $\mathfrak{D} = 2.87$ GHz (SC-019c, L80),

$$\mathfrak{H} = \frac{9}{8\mathfrak{D}^2} \left[2A_{\perp}^2 + (A_{\parallel}^2 - A_{\perp}^2) \sin^2 \mathfrak{E}_{\text{hf}} \right], \quad (31)$$

$$\Delta \ln \mathfrak{D}_{\text{centroid}} = \ln(1 + \mathfrak{H}) \simeq 7 \times 10^{-3}.$$

This is the second-order centroid displacement, not a density response of the bare splitting. The fit keeps it in the hyperfine terms once. Exact diagonalisation of Eq. (13) at zero field plus the added Hamiltonian, the three nuclei taken together, shows that the neglected orders in $A/\mathfrak{D}$ add 1%, so this second-order value carries one figure. Each plate's thermal slope corrects its temperature; line splitting and width bound strain, and a nitrogen assay bounds the paramagnetic channel. The carried-clock frequency is not inferred from the medium's temperature.

With illustrative corrected plate scatter $\mathfrak{s}_{\text{plate}} = 10^{-4}$ (U-09), three plates per group and equal scatter, the Welch degrees of freedom are four. At the constant $S_{\mathcal{M}} = 1$ test point (U-12), the solved

predictions and comparison precision are

$$\begin{aligned} (\Delta \ln \mathfrak{D})_{\text{density}} &= 0.0803, & (\Delta \ln \mathfrak{D})_{\text{ablated}} &= 0, \\ \mathfrak{d}_{\text{HL}} &= 8 \times 10^{-5}, & \mathfrak{z}\mathfrak{d}_{\text{HL}} &= 2 \times 10^{-4}. \end{aligned} \quad (32)$$

The uncertainty estimates retain the assumed scatter's one significant figure. The stochastic contrast is the full density shift; the common conventional contribution cancels between the FDT and ablated computations. This is conditional by construction on the declared sensitivity and bound. The experimental detection rule also requires exceeding the conventional 0.01 envelope (U-11). Exclusion uses the widened density interval, and attribution uses the assayed mixed-mass fraction with the shared-light and assay covariance and the two-degree Student criterion above. The seeded detection simulation at the positive conventional bound returns false rejection 0.018 for equal scatter and 0.026 for a scatter ratio of 3, versus nominal upper-tail 0.025 (U-09, U-15, U-16). Per-plate corrections are included in the simulated scatter once. The excess is resolved well above the block's own Student uncertainty; a null excluding the widened test-point interval rejects this instantiated density response, not every possible sensitivity.

5.7 T-5: isotope dependence of static diamagnetism

DC-5 discriminates SA-85: the source sets aside the slab's spin-independent diamagnetism, leaving its isotope response unmeasured. The author's constitutive input is I-7's equilibrium density channel. Grow the same three heavy, three light and three mixed plates in one campaign (U-09), now NV-free, cut to the reported $3 \times 3 \times 0.5$ mm slab dimensions (SC-071c, L353). Keep the light off. In the source's resonator move the cylinder from far away to $\mathfrak{h} = 0.5$ mm (SC-055, L267), and obtain the static diamagnetic force F_{dia} from displacement times $\mathcal{K} = \mathcal{M}\omega_0^2$ measured per mount. Use the magnitude of the repulsive force so the logarithm is defined. The observable is $\mathfrak{o} = F_{\text{dia}}/V$, with each slab's measured volume V , independent of its carbon-mass assay.

The defining condition is

$$\Delta \ln(F_{\text{dia}}/V) = \int (S_{\mathcal{M}} d \ln \mathcal{M}_C + S_{\text{lat}} d \ln \mathfrak{l} + S_{\text{zp}} d \ln \mathfrak{w}). \quad (33)$$

For this observable, its three sensitivities respectively hold lattice constant and zero-point amplitude, mass and zero-point amplitude, or mass and lattice constant fixed. The conventional susceptibility change retains lattice and zero-point renormalisation within the illustrative 0.01 bound (U-11) and sets the density sensitivity to zero. At fixed declared exterior radius, the author's density route supplies the positive mass-log integral. With $S_{\mathcal{M}} = 1$ constant on that path (U-12), corrected plate scatter $\mathfrak{s}_{\text{plate}} = 2 \times 10^{-3}$ (U-09), three plates per group and four Welch degrees of freedom at equal scatter, the solution is

$$\begin{aligned} [\Delta \ln(F_{\text{dia}}/V)]_{\text{density}} &= 0.0803, & [\Delta \ln(F_{\text{dia}}/V)]_{\text{ablated}} &= 0, \\ \mathfrak{d}_{\text{HL}} &= 2 \times 10^{-3}, & \mathfrak{z}\mathfrak{d}_{\text{HL}} &= 5 \times 10^{-3}. \end{aligned} \quad (34)$$

This is conditional by construction. The same conventional term appears in both computations and cancels from their contrast. The difference also exceeds the block's own Student uncertainty.

Measure each slab's mass and volume, subtract its nitrogen Curie term, measure the bare rod's displacement, and bound magnet temperature, mount height and lateral offset. Propagate these inputs with per-mount stiffness and displacement into $\mathfrak{d}_{\text{HL}}$, preserving shared field calibration covariance. The illustrative scatter already contains the per-plate temperature and volume errors. Detection requires the measured absolute shift to exceed the conventional envelope plus $\mathfrak{z}\mathfrak{d}_{\text{HL}}$. Exclusion requires the data interval and density test-point interval widened by the envelope to be disjoint. Attribution requires the mixed-minus-light shift to follow its assayed log-mass fraction of the heavy-minus-light

shift within $t_{0.975,2}\mathfrak{D}_{\text{mix}}$, with assay errors and the common light-group covariance included. At the positive comparator bound the same scale-invariant seeded rule returns false rejection 0.018 at equal scatter and 0.026 at scatter ratio 3, compared with nominal upper-tail 0.025 (U-09, U-15, U-16). A null satisfying exclusion rejects the instantiated response including its conventional-channel allowance. Its inference uses plate replication, not the number of displacement samples.

6 Cross-domain consequences

The carrier identity connects the optical preparation and its lattice settlement. For numerical conversion use exact $h = 6.62607015 \times 10^{-34}$ J s and elementary charge $e = 1.602176634 \times 10^{-19}$ C (U-02); the electron rest-mass input is $m_e = 9.1093837015 \times 10^{-31}$ kg (U-03). The other constants entering the estimates are $G = 6.67430 \times 10^{-11}$ m³kg⁻¹s⁻² (U-04) and $\sigma_{\text{SB}} = 5.670374419 \times 10^{-8}$ W m⁻²K⁻⁴ (U-05). These are assumed external metrological inputs [3]. Equation (1) gives the derived electron Compton length $\ell_e = 2.426$ pm, without assigning it a support. The stroke quantum is $hc/\mathfrak{W}$ and its grade radius is $\mathfrak{W}/(2\pi)$. Three-figure wavelengths license the table’s three-figure energies and radii.

Reported wavelength	Derived energy	Derived grade radius
532 nm (SC-028a, L152)	2.33 eV	84.7 nm
637 nm (SC-077b, L395)	1.95 eV	101 nm
980 nm (SC-077a, L393)	1.27 eV	156 nm

The derived pump excess over the line is 0.38 eV; the infrared shortfall is 0.68 eV. The author’s reading is that the excess settles into the lattice through the same carrier. The source’s cited magnon–microwave precedents (SC-007a, L24; SC-007b, L25; SC-007c, L31) also occupy that identity; they are not measurements in this apparatus. Its approximate ensemble count is printed with a flattened exponent (SC-007d, L32); the “huge spin ensemble” wording supports the positive count reading. Those cited precedents add no numerical calibration here. The optical energies are identity conversions and corroborate no invariant. An energy balance with an independently identified additional carrier would falsify the I-2 reading at the balance’s measured precision.

The following measurements converge with the standard calculation and are separate from the five predictions. A uniform coil field at fixed gradient changes the force only through the moment, which must be read independently at the same spot. A [111] slab puts one family on axis and three at the derived $\arccos(1/3) = 70.5^\circ$; the source’s aligned pumping remains “predominantly” into $m_s = 0$ (SC-029a, L158; SC-029b, L159), and ΔF follows the source’s seven-level rate model (SC-036a, L202) at those angles. At equal force, power, duty and gap, evacuation changes amplitude in proportion to $\mathcal{Q}$. The source says the oscillator “can oscillate” up to about 1.5 μm in vacuum and “as large as” about 100 nm in air (SC-011c, L57; SC-011a, L58; SC-011b, L59); their amplitude ratio rounds to 2×10^1 at one figure. Its evacuated drive and quality factor are unprinted.

Reversing the beam at fixed spot, intensity and crystal-relative polarisation reverses the vertical photon momentum contribution, at most $2\mathcal{P}/c = 0.33$ nN for 50 mW (SC-042b, L180); the settled spin force stays unchanged. The source reports that the green laser’s polarisation fluctuates $\pm 5^\circ$ over time (SC-090, L388; SC-076, L389), so a beam tilt also requires that polarisation control. Microwave inversion of the held moment makes the gradient force repel in the standard calculation. The source’s proposed full transfer is “potentially giving rise to a stronger force” (SC-066b, L403). The light also changes stiffness: define $\Delta\mathcal{K}$ as its local stiffness change and $\Delta_{\text{on}}f_0$ as the corresponding frequency change. With ΔF positive toward decreasing gap, linearization about the same equilibrium gives

$$\Delta\mathcal{K} = \partial_{\mathfrak{h}}\Delta F, \quad \Delta_{\text{on}}f_0 = \frac{f_0}{2\mathcal{K}}\partial_{\mathfrak{h}}\Delta F. \quad (35)$$

The derivative is measured locally; two gaps supply a secant unless a linear profile is established. Finally, repeat the infrared control at matched absorbed heat, using the slab’s measured temperature

rise, and use an NV-free slab under green drive with the magnet present. These close the heating channels that a wavelength change alone leaves open. This whole family is an I-4 identity comparison, corroborating no invariant; each independently calibrated failure tests its stated response or control assumption at the propagated experimental precision.

7 System-level reading (exploratory)

Scope: this section contains only the in-sample reconstruction of the source’s existing mechanical drive. The author’s helical-window factor is multiplied by Earth’s lapse to define $\mathcal{V}_{\text{clk}}$.

X-1. Three spatial readings of the clock factor. The observable is the slope and curvature (the level at a point is invisible, 0.1c) of $\ln \mathcal{V}_{\text{clk}}$ relative to the fixed interferometer head. Its defining condition is Eq. (21) in the static slow limit; its comparator is the source’s ordinary driven oscillator with the same inputs. Define $\mathcal{C}_{\oplus}$ as Earth’s log-clock slope, $\mathcal{C}_{\text{trap}}$ as the trap contribution to the second spatial derivative and $\mathcal{C}_{\text{light}}$ as the magnitude of the light-switched slope. Then

$$\begin{aligned}\mathcal{V}_{\text{clk}} &= \sqrt{1 - \alpha_{\text{ext},\oplus}} \mathbf{m}, \\ \mathcal{C}_{\oplus} &= G\mathcal{M}_{\oplus}/(R_{\oplus}c)^2 = 1.0927 \times 10^{-16} \text{ m}^{-1}, \\ \mathcal{C}_{\text{trap}} &= \omega_0^2/c^2 = 1.36 \times 10^{-13} \text{ m}^{-2}, \\ \mathcal{C}_{\text{light}} &= \Delta F/(\mathcal{M}c^2) \simeq 4 \times 10^{-22} \text{ m}^{-1}.\end{aligned}\tag{36}$$

The first slope uses U-07’s five-figure radius; the trap curvature uses the three-figure f_0 (SC-020b, L82); the switched slope uses the one-figure amplitude (SC-042c, L186). Each reconstruction uses the unrounded Eq. (17) force from $\eta = 48.73\%$ (SC-081a, L236), $\mathcal{Q} = 55$ (SC-020c, L86) and $\mathcal{M} = 128 \text{ mg}$ (SC-020a, L81). Define $\mathcal{Z}$ as the fundamental’s resonant gain relative to the static well displacement. The resulting in-sample comparisons are

$$\begin{aligned}\frac{\Delta F}{G\mathcal{M}_{\oplus}\mathcal{M}/R_{\oplus}^2} &\simeq 4 \times 10^{-6}, & \Delta F/\mathcal{K} &\simeq 3 \text{ nm}, \\ \mathcal{Z} &= \frac{2}{\pi} \mathcal{Q} \sin(\pi\eta) = 35.\end{aligned}\tag{37}$$

The gain retains the quality factor’s two figures; the other two results retain the amplitude’s one figure. A uniform level changes no energy gradient; the light changes the slope and, through $\partial_{\mathbf{h}}\Delta F$, the curvature (Eq. (35)). The author’s reading is that the checkerboard holds the resonator in the laboratory flow while the light rewrites its fall by rewriting its moment.

Guards. The source says “exceeding 100 nanometers” in its abstract (SC-004, L19) and approximately 100 nm at the trace locus (SC-042c, L186). The force is the response estimate, and the helical energy window is the author’s construction. These three slopes recover the same in-sample oscillator. They corroborate no invariant and contribute no prospective prediction. An independent force–energy-gradient discrepancy is the falsifier for the construction, with the full joint uncertainty.

8 Convergence statement

On the source Hamiltonian, population rates, cylinder field and response dictionary, Eqs. (13), (16) and (17) return its conventional forces, amplitudes and spectra. The source’s 128 mg, 17.6 Hz and $\mathcal{Q} = 55$ are apparatus inputs (SC-020a, L81; SC-020b, L82; SC-020c, L86); the trace amplitude and forces are estimates, the populations and field are simulations, and the common division by 1.2 makes

the compared curves in-sample (SC-042c, L186; SC-058e, L308; SC-036d, L206; SC-035b, L196; SC-037b, L174). The motion direction and control spectra are accepted with their reported conditions. Supplementary rates, field maps, evacuated settings and heating details supply no additional numbers here. The moment sign, basis adjoint and amplitude convention are kept explicit, and the source's time-versus-frequency comparison (SC-017d, L23; SC-007a, L24) is read dimensionally as a time versus period condition, not quoted as a measured inequality. This recovery is the identity map of Use item 2 and corroborates no invariant. For the same stress tensor and data, Earth's curvature is I-3 containment; at leading weak-field, slow-motion order the force reduction is I-4 containment. The additional twist source and isotope constitutive input are the divergences.

The source frames mechanically linked spin and motion as hybrid quantum systems (SA-01; SC-002a, L13; SC-002b, L14). FDT reads one medium in different dynamical limits (I-4); its coupled oscillator data are accepted and recovered above.

The source calls levitated systems in vacuum an ideal platform because of ultralow damping (SA-12; SC-013a, L53; SC-013b, L54). FDT reads the evacuated chamber as reduced air-pattern density in the omnium (0.1b); the damping benefit is accepted without an empty background.

The source describes proposals to engineer macroscopic spatial superpositions (SA-13; SC-014a, L50; SC-014b, L51; SC-014c, L52; SC-013a, L53). FDT reads superposition as ignorance of helical phase (I-4); the source's classical driven-motion data and the proposal status remain intact.

The source says such superpositions have the potential to test the quantum nature of gravity (SA-14; SC-015a, L55; SC-015b, L56; SC-015c, L57). FDT reads quantized energy and path content through one carrier and the fixed strand rate (0.1a, I-2); the proposed experiments retain their measured observables without a separately quantized gravitational carrier.

The source says macroscopic motional superpositions have the potential to test the boundary of quantum mechanics, and that by using coherent microwave control techniques and shorter laser pulses the spurious effects on the mechanical motion arising from laser-induced heating of the oscillator can be substantially mitigated, and one could then envision engineering coherent energy exchanges between spin and mechanics with, eventually, tests of macroscopic nonclassical states of motion (SA-15; SC-015a, L55; SC-015b, L56; SC-015c, L57; SC-016, L58; SC-066f, L404; SC-066c, L405; SC-066d, L406; SC-066e, L407; SC-066g, L408; SC-088, L410; SC-089, L411). FDT reads the classical and quantum descriptions as limits of one form (I-4); the present harmonic-motion data are recovered without a boundary between two substances.

The source lists searches for exotic forces or dark matter among the proposals (SA-16; SC-016, L58; SC-017a, L60). FDT reads dark matter as heavier, denser omnium, the mass shadow compressed around matter with no particle content (0.7, I-7), and every interaction as one force law (I-1); the source's laboratory force data remain accepted and carry no dark-matter detection.

The source assigns a force to a single spin's magnetic moment in a field gradient (SA-21; SC-021a, L88; SC-021b, L90; SC-022a, L92). FDT reads a configuration's circulating projection in the energy gradient (P-5, I-5); the source moment formula is the recovered observable dictionary, not an intrinsic particle property.

The source integrates the collective effect of the spins over the diamond (SA-24; SC-024a, L96; SC-024b, L97; SC-024c, L98). FDT reads the event as system-wide, many-to-many settlement (0.1a); its weighted force integral is recovered as bookkeeping for the same data.

The source describes the thermal spin ensemble by a density matrix, and its eigenstates "become mixed" at strong off-axis fields (SA-25; SC-025a, L100; SC-025b, L107; SC-029d, L161; SC-029e, L162). FDT reads the underlying configurations and their phase ignorance (I-4); those matrices retain their conventional role in reproducing the same thermal and driven observables.

The source states that the cylinder generates a static magnetic field and a magnetic field gradient (SA-86; SC-085, L90; SC-086, L91). FDT reads that field as the omnium's helical density geometry (P-5), not a separate entity; the measured motion and the field-model force dictionary are recovered in full.

9 Status ledger

The table states the operative statuses and convergence values.

Item	Status and content
O-1	The finite-core cutoff r_c , the regular core chart, or the outward phase-transfer law are owed; only the atlas domain uses them.
O-2	A geometrically constructed odds for the overlap-contrast application (A-3) is owed.
O-3	A canonical odds for the confinement application (A-4) is owed.
O-5	Multipole and tidal remainders of the closed-form pair expression, and the reading they give of the band outside a rotating source's horizon; the overlap complex; how P-4's many-cone settlement signs a pair it does not join, are owed. Weight uses the declared monopole domain.
O-6	The maps from a charge or a colour seat to an I-1 input; derivation of the seat table from cone geometry; the gluon octet's dynamics are owed. The magnetic input map supplies no numerical force here.
O-8	The constitutive derivation of $c_{\text{eff}}/n_{\text{cone}}$ and its reconciliation with lensing are owed. The exact optical metric remains operative.
O-9	The confinement operator D , its domains, boundary data and spectrum; every mass ratio, including the two held-out targets, are owed. Splitting and optical-line costs are mode differences; no mass ratio is a result here.
O-12	The phase-exchange rates and the decay kernel, spectrum, chirality and rates are owed. Population kinetics here use the source model.
O-14	The mass-shadow response function and its closure, and the release function of 0.7 (which bodies unwind, their mass-loss rate density and their compression contrast), are owed. The convergence statement's dark-matter reading uses the mass shadow only and quotes no response.
T-1	Prospective, conditional by construction; torsion-field existence, conventional double-odd value zero. P-5: "Quantitative twist $\rightarrow$ moment forms are derived in-manuscript through I-1/I-2 with a declared kernel." No quantitative kernel is declared.
T-2	Prospective, conditional by construction; helical-rod-field existence, conventional zero. P-5: "Quantitative twist $\rightarrow$ moment forms are derived in-manuscript through I-1/I-2 with a declared kernel." No quantitative kernel is declared.
T-3	Prospective, conditional by construction; bonded-blade-field existence, conventional zero. P-5: "Quantitative twist $\rightarrow$ moment forms are derived in-manuscript through I-1/I-2 with a declared kernel." No quantitative kernel is declared.
T-4	Prospective, conditional by construction; author's density contribution at the stated constant-sensitivity test point, conventional density contribution zero with its separate channel envelope.
T-5	Prospective, conditional by construction; author's static diamagnetic density contribution at the stated test point, conventional density contribution zero with its separate envelope.
X-1	In-sample clock-factor slopes; converges exactly to the source-input oscillator.
Energy window	Author's construction, in-sample; the slow magnetic term is the source force identity.
A-3, A-4, A-5	PROVISIONAL tokens: open ranges only, unused for numbers, thresholds, ordering, signs or trajectories.

10 Conclusions

The laser changes the configuration whose energy is compared across the magnetic gradient. In the author's helical-window construction that rewrites the resonator's fall; its slow force and resonant response recover the source's equations. Heat energy, optical momentum, induced diamagnetism and the pumped moment retain separate, singly counted roles. The displacement record determines a driven response, while populations, field profiles and force conversion retain their model dependence.

The five prospective blocks add concrete physical inputs. Static twist supplies a field source in three distinct geometries, tested with complete hand, bias, light and shape reversals and explicit residual bounds. The two isotope blocks add an equilibrium density sensitivity and test its finite path integral against conventional lattice and zero-point channels. Their detection, finite exclusion and mixed-composition attribution rules preserve those distinctions. The in-sample clock-factor reconstruction carries no additional prediction.

References

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- [4] IERS Conventions (2010), Earth gravitational-parameter convention; U-07 includes the stated mean-radius convention.
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- [6] S. Felton et al., *Physical Review B* **79**, 075203 (2009), first-shell carbon hyperfine parameters, illustrative inputs U-14.