

Giant domain walls in a cuprate: density channels, structural reconstruction and discriminating measurements

FDT analysis

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Abstract

Ladbrook, Wright and Senn reconstruct extended bands of near-zero orthorhombic strain and low-temperature stripes in LESCO by scanning three-dimensional x-ray diffraction [1] (SC-035, SC-063). The declaration is `source_status: experimental`; measured, observed and reported designate source results, while derived, estimated, reconstructed and illustrative-assumed distinguish the other quantities below. Fundamental Density Theory (FDT) reads matter, energy and spacetime as omnium. This manuscript’s reading treats the crystal and its twins as one pattern with boundary-selected nodal architecture. The measured reflection dictionary returns the source’s structural maps unchanged; a near-zero strain band alone leaves tilt rotation, amplitude reduction and instrumental averaging unresolved. Four prospective predictions, conditional by construction, test additional inputs: corrected copper- and oxygen-isotope shifts of domain strain, a hand-odd axial field from physical torsion, and a corrected copper-isotope shift of wall width. The density-coupled structural responses and the direction of the torsion field are this manuscript’s readings of the core clauses. Their magnitudes remain conditional response integrals; specified exclusion effects serve as experimental test points. A local unit-cell-volume candidate has no constitutive map and is retired. One uncounted exploratory observable relates the two reconstructed microstructures to global settlement.

1 Framework

The target crystal is $\text{La}_{1.675}\text{Eu}_{0.2}\text{Sr}_{0.125}\text{CuO}_4$, described as a prototypical one-eighth-doped cuprate (SC-001, SC-002, L18) [1]. The locked core [2] states, in clause 0.1b, “There are no separate particles and no boxes: there is only omnium, and omnium patterns.” It defines a room, cell, domain or grain as a pattern’s support region with its own boundary data. This manuscript’s reading makes the whole crystal one pattern and treats its twin boundaries as internal support data. A crystal twin domain, an I-5 confinement domain and a universal domain name different objects. A structural phase, helical phase and matter–spacetime phase likewise retain their separate meanings.

1.1 Notation guard

The following census fixes the source vocabulary before its use in equations. Upright crystallographic labels are labels, not new scalar variables. The ledger identifiers SC designate source claims, U assumed inputs, SA source under-determinations, and DC candidate experiments; record loci are written L followed by their physical line. The symbols in the last row are defined in their experimental sections. In the equations Δ denotes a finite increment, O an asymptotic remainder, π the circle constant and $g_{\mu\nu}$ metric components; μ, ν are tensor indices. The operators Var and Cov denote variance and covariance, and ∞ denotes the unbounded integration endpoint.

Source token	Meaning	Name used here and reserved role
Tilt amplitude	Order-parameter direction	$\mathbf{t}$, components t_1, t_2 ; a is the radiation constant.
X-point irreps	Structural mode labels	X_3^+, X_4^+ ; X is gap odds.
Γ labels	Strain modes	$\Gamma_1^+(1), \Gamma_1^+(2), \Gamma_2^+, \Gamma_4^+, \Gamma_5^+(a), \Gamma_5^+(b)$; no cable or rate uses this letter.
Cell edges, axes	Lattice geometry	Words and Miller directions; c is the strand rate.
Miller indices	Reciprocal-lattice indices	$\mathbf{h}, \mathbf{k}, \mathbf{l}$; h is Planck's constant, k a wavenumber.
Scattering angle	Twice the Bragg angle	2Θ ; θ is the optical angle.
Azimuth	Detector angle	η .
Sample rotation	Rotation scan	$\mathbf{w}$; ω is frequency.
Sample translation	Translation scan	$\mathbf{z}$; y remains the core diagnostic input.
Series index	Cuprate homologous index	$\mathbf{n}$; n is strand count.
Doping variable	Composition or deficiency	Chemical subscripts, or $\mathbf{x}$; x remains the odds-enhancing input.
Transition temperature	Superconducting transition	T_c , a temperature; T labels experiments.
B, Ba, Bi	Centering, class or element	Upright words; B is boundary data, $\mathbf{B}$ the magnetic field.
A	Centering, site or class	Upright words; A labels chart applications.
Supplementary S	Figure or table identifier	Label only; S_i is a response sensitivity.
L and compounds	LTO, LTT, LESCO, La	Words; L1–L3 designate core recovery layers.
D in 3DXRD	Diffraction acronym	Word; D is the confinement operator.
T, R, W	Abbreviations or elements	Words; no scalar reassignment.
Micro prefix	SI length prefix	Upright μm ; μ_0 is permeability.
Experimental quantities	Shifts, corrections, contrast	$\mathfrak{h}, \mathcal{N}, \mathfrak{C}, \mathfrak{r}, \mathfrak{u}, \mathfrak{B}, \mathfrak{Q}, \mathfrak{b}$; defined before use.

1.2 Bridges, closure and the stroke

Clause 0.1a says “The bridges are constants of the medium and are always displayed.” Let E_q, m_q, ω_q be a mode's energy, mass and angular frequency, T_q its period and ℓ_q its Compton length; q labels a mode. The constants $h, \hbar = h/(2\pi), c, \epsilon_0, \mu_0$ are Planck's constant, its reduced form, the strand rate and the two response coefficients. The quantities d, t denote a thread distance and its duration, not specimen size or temperature. The general energy and mass are

E, m . Then clauses 0.1a and 0.1d give

$$E_q = m_q c^2 = \hbar \omega_q, \quad T_q = \frac{2\pi}{\omega_q} = \frac{h}{E_q}, \quad (1)$$

$$\ell_q = c T_q = \frac{h}{m_q c}, \quad \frac{E}{m} = c^2 = \frac{1}{\epsilon_0 \mu_0} = \left(\frac{d}{t}\right)^2, \quad (2)$$

$$\frac{d}{t} = c = 299792458 \text{ m s}^{-1}. \quad (3)$$

Here c is “the rate at which the one stroke runs, measured on the spot” (0.1d). For the electron $q = e$, T_e , ℓ_e and ω_e denote its period, Compton length and angular frequency; the assumed rest energy is $E_e = 510.99895000 \text{ keV}$ (U-01). Using the Planck and charge conventions U-02 gives the derived bridge values

$$T_e = 8.09330 \times 10^{-21} \text{ s}, \quad (4)$$

$$\ell_e = 2.42631 \times 10^{-12} \text{ m}, \quad (5)$$

$$\omega_e = 7.76344 \times 10^{20} \text{ s}^{-1}. \quad (6)$$

These deliberately rounded values are a period, a thread length and an angular frequency; the thread length is the Compton length, never the support R_{box} . The two rounded response constants U-05 give $1/\sqrt{\epsilon_0 \mu_0} = 299792458.00 \text{ m s}^{-1}$, consistent with the exact strand rate at their stated precision. The confinement spectrum, rather than a discretisation of the chart, carries quantised mass; the null periods and paths have the one-sided infima specified in 0.1a. The standing kinematic and Clifford constructions are those of 0.1d and I-4 [2]. They include closure stress in inertia, distinguish translation from the internal run, and distinguish the single-angle phase rotor from a spinor rotor. No magnetic-field symbol is assigned to a phase bivector here.

Read as carriers, the chain of clause 0.1, displayed in Eq. 2, with the one medium of clause 0.1b, gives I-2: “photon = graviton = gluon = phonon = magnon.” The x-ray stroke and lattice phonon are that stroke in different regimes. There is no mediation and no carrier exchange. The open stroke keeps no time; its grades turn at the radius fixed by its angular frequency. No x-ray energy is specified by the source, so this analysis evaluates no x-ray stroke radius. I-4 states: “The universe is deterministic; there are no probability amplitudes.” This manuscript’s reading takes the structure factors as field amplitudes scattered by the crystal’s pattern. I-4’s exact two-body reduction, weak-field expansion and source programme remain its distinct L1, L2 and L3 layers.

1.3 Chart inventory and gravitational faces

Let G be the gravitational constant, F_{max} the maximum-force scale, $\mathcal{M}$ total gravitating content and R_s its Schwarzschild length. The field-point radius r_f , the interior cutoff r_c and the branch tag σ retain their core meanings. The exterior and interior curvature ratios are α_{ext} and α_{int} ; α_σ denotes either branch. The chart is fixed by two lengths before an observable is consulted

(0.3).

$$F_{\max} = \frac{c^4}{4G}, \quad R_s = \frac{2GM}{c^2} = \frac{\mathcal{M}c^2}{2F_{\max}}, \quad (7)$$

$$\alpha_\sigma(r_f) = \left(\frac{R_s}{r_f}\right)^\sigma, \quad 0 < \alpha_\sigma < 1, \quad (8)$$

$$\alpha_{\text{ext}} = \frac{R_s}{r_f}, \quad \sigma = +1, \quad R_s < r_f < \infty, \quad (9)$$

$$\alpha_{\text{int}} = \frac{r_f}{R_s}, \quad \sigma = -1, \quad r_c \leq r_f < R_s. \quad (10)$$

Let $X_{\text{ext}}, X_{\text{int}}$ be the geometric gap odds and X_σ the branch-selected odds. The computational bounded coordinate is β_σ . The two branches give the following exact maps (0.3–0.4):

$$X_{\text{ext}} = \frac{R_s}{r_f - R_s}, \quad X_{\text{int}} = \frac{r_f}{R_s - r_f}, \quad (11)$$

$$\alpha_\sigma = \frac{X_\sigma}{1 + X_\sigma}, \quad \beta_\sigma = \frac{\alpha_\sigma}{1 + \alpha_\sigma}. \quad (12)$$

The following chart inventory is the complete application declaration. The overlap, confinement and mode tokens $\alpha_{\text{ovl}}, \alpha_{\text{conf}}, \alpha_{\text{mode}}$ have only their open range. The diagnostic α_{core} denotes the nuclear skin limit, not the central density.

Application	Token	Geometric warrant and use
A-1	α_σ	Yes; source exterior, field-point evaluation and configuration interior kept separate.
A-2	β_σ	Yes; computational coordinate, unused in force, optical or density slots.
A-3	α_{ovl}	No; token and range only.
A-4	α_{conf}	No; token and range only.
A-5	α_{mode}	No; token and range only.
Skin diagnostic	$\alpha_{\text{core}} \rightarrow 1^-$	Schematic saturation of the nuclear interior skin.

No chart is assigned to strain, tilt amplitude, a histogram, wall width or a critical tilt. I-1a's overlap threshold belongs to A-3, not to the crystallographic change. I-6 states “One symbol, one meaning” and requires the open interval without exceptions. The rational odds map preserves that interval without a fitted response entering either length.

For I-3's optical face let s_{opt} denote optical path length and dS_{ang}^2 the unit-sphere angular line element; the suffix distinguishes it from the confinement domain. For its tensor face $G_{\mu\nu}$ is the Einstein tensor, $T_{\mu\nu}$ the stress tensor and κ the Einstein coupling. The optical indices $n_{\text{iso}}, n_{\text{cone}}$ are the core's named indices, distinct from strand count n .

$$ds_{\text{opt}}^2 = \frac{dr_f^2}{(1 - \alpha_{\text{ext}})^2} + \frac{r_f^2 dS_{\text{ang}}^2}{1 - \alpha_{\text{ext}}}, \quad (13)$$

$$G_{\mu\nu} = \kappa T_{\mu\nu}, \quad \kappa = \frac{8\pi G}{c^4}, \quad (14)$$

$$n_{\text{iso}} = 1 + \alpha_{\text{ext}} + O(\alpha_{\text{ext}}^2), \quad n_{\text{cone}} = (1 - \alpha_\sigma)^{-1/2}. \quad (15)$$

The first index uses the weak isotropic optical dictionary; the second retains its constitutive status in the status ledger. The cone index is never inverted into a material strain. For two

optical regions let $\mathcal{I}_1, \mathcal{I}_2$ denote their exact indices and θ_1, θ_2 their ray angles. The exact Snell relation of I-3 reads

$$\mathcal{I}_1 \sin \theta_1 = \mathcal{I}_2 \sin \theta_2. \quad (16)$$

The tensor equation is unchanged, and α_σ is downstream of its solution (I-3). The clock factor $\mathbf{m}$ rescales the metric $g_{\mu\nu}$ as $g_{\mu\nu} \mapsto \mathbf{m}^2 g_{\mu\nu}$ (0.1c). Kept time and thread length rescale together, leaving their ratio fixed; 0.1c states that “moving at constant speed, on the pattern’s own clocks and rulers, through a density gradient is gravity”, and a reading of curvature, a tide or a density gradient is a comparison of neighbouring patterns, or of a pattern with a reference path (I-3a). The bookkeeper’s flow is present at laboratory sizes as well as large sizes. The perfect-stress premise for reading a medium clock factor from temperature or enthalpy per conserved count is not established by a strain reconstruction in a solid. Neither such medium quantity is the fractional shift of a clock the crystal carries.

1.4 Force, confinement and channel content

For the two bodies let α_1, α_2 be their geometric interaction inputs and F their force. I-1 gives its universal law and bound:

$$F = \frac{c^4}{4G} \alpha_1 \alpha_2 = F_{\max} \alpha_1 \alpha_2 < F_{\max}. \quad (17)$$

For disjoint spherical supports of contents $\mathcal{M}_1, \mathcal{M}_2$, with centre separation d , the inputs are $R_{s,1}/d$ and $R_{s,2}/d$. On this pair domain substitution into Eq. 17 yields the exact L1 reduction

$$F = \frac{G\mathcal{M}_1\mathcal{M}_2}{d^2}, \quad F \leq \frac{F_{\max}}{4}. \quad (18)$$

The interval and universal bound precede the pair-domain restriction; the last inequality reaches equality for saturated equal supports at contact in the boundary limit. For a path coordinate s and starting point s_0 , let $U(s_0)$ denote interaction work and F_s the attraction’s signed component along increasing s . With an integrable force along the path, I-1 defines

$$U(s_0) = - \int_{s_0}^{\infty} F(s) ds. \quad (19)$$

The attraction’s magnitude F and its signed component F_s along increasing s are recovered as

$$F(s_0) = \frac{\partial U}{\partial s_0}, \quad F_s = - \frac{\partial U}{\partial s_0} = -F, \quad (20)$$

both for almost every s_0 when the force is locally integrable and at every s_0 when it is continuous. A coefficient becomes energy only after its energy channel and path are specified. The source’s wall-energy language supplies no such force-to-wall-energy kernel (SC-076-a, L267).

The confinement domain is Ω , its boundary data B , strand count n , orientation χ and position t on the inside/outside chart. The operator D , eigenmode u_q and eigenfrequency ω_q define I-5’s eigenproblem:

$$D(\Omega, B; n, \chi, t) u_q = \omega_q u_q, \quad m_q c^2 = \hbar \omega_q. \quad (21)$$

An ionic closed pattern has this confinement meaning. A same-strand-count change changes configuration within a class; changing strand count is a rebraiding into a different class. No particle receives a confinement address, anchor radius or mass formula.

For I-7 let M denote rest content, E additional energy, P pressure, V volume and T temperature. The radiation energy-density coefficient is a and the Stefan–Boltzmann flux coefficient is σ_{SB} . The mass-equivalent ledger is

$$\mathcal{M} = M + \frac{E}{c^2} + \frac{PV}{c^2} + \frac{aT^4V}{c^2} + \cdots, \quad a = \frac{4\sigma_{\text{SB}}}{c}. \quad (22)$$

Each channel enters once; here the thermal part of E excludes the radiation term written separately. Gravitational binding belongs to the geometry and is not added as a local stress contribution. The derived coefficient is $a = 7.565733250 \times 10^{-16} \text{ J m}^{-3} \text{ K}^{-4}$ (U-04, U-02). I-7 says “Mass, energy, temperature and pressure all enter the same R_s .” It also requires the observable sign to follow its response sensitivities, with the density-input sign kept separate. Cooling changes several entries of $\mathcal{M}$ and the field-point radius r_f together: the radiation term fixes only the positive fixed-geometry partial temperature derivative of α_{ext} , and the total temperature derivative of $\ln \alpha_{\text{ext}}$ adds heat-capacity, thermal-expansion and PV terms and is uncalibrated until $r_f(T)$ and the $\mathcal{M}$ channels are measured; I-7 Discipline 1 states “never assign a thermal direction, or call the total negligible, from the partial alone; cooling-side ordering rides a separate bounded coherence coordinate, never ‘lower α ’.”

2 System chart and dimensional scales

Let m_{fu} denote formula-unit mass, Z formula units per indexing cell and V_{cell} its volume. The reported indexing edges are $5.35 \times 5.35 \times 13.2 \text{ \AA}$ (SC-031, L132; SC-031-a, L133). The assumed atomic weights and isotopic masses are U-06 and U-12; $Z = 4$ is the standard structural convention U-14. The unit u is the atomic mass unit, distinct from the eigenmode u_q . Direct stoichiometric sums give the following derived masses, quoted to the decimal place licensed by the atomic weights:

$$m_{\text{fu}}(\text{natural}) = 401.554 \text{ u}, \quad (23)$$

$$m_{\text{fu}}(^{63}\text{Cu}) = 400.938 \text{ u}, \quad (24)$$

$$m_{\text{fu}}(^{16}\text{O}, \text{natural Cu}) = 401.538 \text{ u}. \quad (25)$$

The conversion to kilograms is U-13. The derived cell volume is $V_{\text{cell}} = 378 \text{ \AA}^3$ and the rest density is $\rho = Zm_{\text{fu}}/V_{\text{cell}} = 7.06 \text{ g cm}^{-3}$. Both results retain only the three significant figures of the cell edges.

The illustrative sphere U-07 has volume 1 mm^3 and support radius $R_b = 0.620 \text{ mm}$, the rounded spherical radius. Its derived rest content is $M = 7.06 \times 10^{-6} \text{ kg}$; other I-7 terms are excluded only from this illustrative rest-content evaluation. With G from U-03, the derived force scale is $F_{\text{max}} = 3.02564 \times 10^{43} \text{ N}$. The chart table distinguishes evaluation radius from support data.

Object and chart	Evaluation	Reading
Sphere exterior, A-1	$r_f = R_b$; $\alpha_{\text{ext}} = \mathcal{M}c^2/(2F_{\text{max}}R_b)$	Fixed support and independently given mass.
Contact pair, A-1	$d = 2R_b$; each input uses the opposite centre	Bare force follows Eq. 18.
Crystal interior, A-1	Skin radius R_{room} ; skin at the fold	The source gives no skin-chart radius; no interior value is evaluated.
Nuclear skin	$\alpha_{\text{core}} \rightarrow 1^-$	Schematic interior saturation; distinct from the same nucleus's exterior compactness.

The derived exterior compactness and contact force are

$$\alpha_{\text{ext}}(R_b) = 1.7 \times 10^{-29}, \quad (26)$$

$$F(d = 2R_b) = 2.16 \times 10^{-15} \text{ N}. \quad (27)$$

The small bare force is I-1's correct prediction on these inputs; a measured binding scale requires its own declared response kernel. The two charts share no displayed transfer map and none is used. At the source's 300 K setting (SC-024-b, L93), the illustrative radiation-to-rest ratio is

$$\frac{aT^4V/c^2}{M} = 9.66 \times 10^{-27}. \quad (28)$$

The rounded volume and radius specify an illustrative geometry; the force calculation uses the stated radius and the mass from the stated volume. This evaluates one positive channel at fixed volume, not the total cooling response. It uses the full internal density for the bookkeeping mass, not the local omnium profile.

3 Observation map

3.1 Reconstruction, resolution and the even strain dictionary

Scanning 3DXRD at ESRF ID11 follows the crystal from 300 to 100 K (SC-024, L90; SC-024-a, L91; SC-024-b, L93). For each reconstructed voxel let f denote its local structural field and w the probe weight. I-3's observation-region rule reads

$$\langle f \rangle_w = \frac{\int w f dV}{\int w dV}, \quad 0 < \int w dV < \infty. \quad (29)$$

Here the weight is the beam footprint composed with the reconstruction kernel of the source's reference [27], at the point spread of the source's reconstructions, whose spatial resolution, the source writes, "is at least 70 nm, based on the determined strain resolution" (SC-093, L188). Finite weighted integrals are assumed. Every voxel strain, wall profile and width that this reconstruction procedure returns, on the source's slice or on the crystals proposed below, is a profile-weighted quantity of this kind. The source reconstructs "the local average unit cell parameters" (SC-043, L160). The centering filters and agreement of the two reconstructions operate within this same inverse problem; they add no independent constitutive datum.

The source's Fig. 2 maps 300, 140, 120 and 100 K (SC-091, L184). Its supplement-based spatial resolution is at least 70 nm, based on determined strain resolution 2×10^{-4} (SC-093,

SC-093-a, L188). The earlier 10^{-4} strain resolution is a cited method capability, not the same determination (SC-045, L169). Neither resolution is a statistical falsification threshold.

Let $\mathbf{g}$ denote the reconstructed signed Γ_4^+ amplitude and let $\mathbf{t}_1, \mathbf{t}_2$ be the tilt components already named in the census. The symmetry interpretation is an even coupling,

$$\mathbf{g} \propto \mathbf{t}_1^2 - \mathbf{t}_2^2. \quad (30)$$

The proportionality expresses this manuscript’s symmetry reading of the source’s secondary-strain discussion; no coefficient is determined by it (SC-042, L157; SC-042-a, L158; SC-053, L165). The strain fixes a difference of squares, never a tilt’s sense. A small difference admits a rotation toward equal components, reduced amplitudes, and averaging across an unresolved boundary. The source’s $X_3^+(\mathbf{t}; 0)$ and $X_3^+(\mathbf{t}; \mathbf{t})$ labels distinguish the nominal LTO and LTT directions in that dictionary (SC-019-a, L83; SC-022-a, L90).

The following observation map keeps reconstruction, interpretation and inference separate.

Locus and class	Structural result	Invariant use and discriminant
SC-035, L139; reconstructed	Near-zero bands in the magnitude of orthorhombic strain	I-3 weighted mean; Eq. 30 leaves amplitude and rotation distinct.
SC-036, L141; supplement-reported	Approximately 150 nm thick, separated by 0.5–2 μm	Widths retain the reconstruction kernel; no density chart is assigned.
SC-047, L120; reconstructed	A-centered LTO domain gradually dominates from 300 to 140 K	P-2 boundary-selected rearrangement is the manuscript’s reading.
SC-050, L132; reconstructed interpretation	Overall microscale variation in Γ_4^+ “appears to be lost” at the lower-temperature maps	The source calls this consistent with a more homogeneous LTT structure.
SC-063, L200; reconstructed	Stripelike orthorhombic features on the 100–200 nm scale	P-2 reading of a distinct settled architecture.
SC-068, L226; reconstructed	Only negative Γ_4^+ present at 100 K	A-twin sign convention, not a winding direction.

Corroboration statement for this cluster: the source-input reconstruction is the identity map of core Use item 2 and corroborates no invariant. I-3 supplies the weighted-interior dictionary, with precision limited by the kernel and the stated resolutions; a reconstruction that fails the same forward reflection model falsifies the proposed structural assignment. The discriminating measurement below tests that assignment within the conventional dictionary.

3.2 Broad walls and the convergent symmetry measurement

The source writes that the walls “are effectively extended LTT-like regions coexisting within an LTO matrix” (SC-039, L148). It says their substantial thickness “could even give rise to coherent scattering signals observable as distinct phases” (SC-040, L149; SC-040-c, L150; SC-040-a, L151). That modal attribution does not turn a strain minimum into an independent LTT reflection measurement. The source’s coherence refers to diffraction; it is not the bounded coherence coordinate of I-7.

DM-1 is a convergent measurement on the same slice at 300 K (U-10; SC-024-b, L93). Measure LTT-allowed reflections with $\mathbf{h} + \mathbf{l}$ and $\mathbf{k} + \mathbf{l}$ both odd and with $\mathbf{h}, \mathbf{k}$ nonzero. The standard structural account allows (110), (112) and (221) in $P4_2/n\text{cm}$ while both LTO twins forbid them (U-10). The odd- $\mathbf{l}$ $0\mathbf{k}\mathbf{l}$, $\mathbf{h}0\mathbf{l}$ and $00\mathbf{l}$ reflections remain extinguished. Alongside these maps, measure reflections allowed by only one twin and normalise each intensity within

its own twin. Their summed normalised intensity is one across a blurred sharp boundary and across a fixed-amplitude rotation, but falls below one for reduced tilt (U-10). The LTT-specific signal then separates rotation toward the LTT direction from the blurred boundary; the summed intensity separates rotation from amplitude loss. The sharp-edge kernel is reconstructed through the same procedure before assigning an extended wall. This resolves the strain-only ambiguity without adding an FDT constitutive parameter. Corroboration statement: the parity filter and intensity comparison use the source’s diffraction dictionary, at the precision of the measured sharp-edge kernel and of their reflection intensities, and corroborate no invariant; disagreement with those extinctions or the measured kernel falsifies the corresponding wall assignment.

3.3 Cooling, stripes and a separate warming leg

The source writes that upon cooling to approximately 160 K, LESCO undergoes a first-order phase transition from LTO to LTT (SC-021, L86). Its 140 K and 120 K maps instead bracket the change after which, in the source’s words, the overall microscale variation in Γ_4^+ “appears to be lost”, while, the source writes, at 100 K, within the CDW phase, the microstructure evolves markedly and deviations from ideal tetragonal symmetry emerge as fine stripelike orthorhombic features (SC-047, L120; SC-050, L132; SC-050-a, L131; SC-063, L200; SC-063-a, L197). These are different statements: an approximate nominal transition and an observed sequence of reconstruction settings. The source writes that the absence of positive Γ_4^+ “implies that the domain sequences must be of the form” $(-\mathfrak{t}; \mathfrak{t})|(0; \mathfrak{t})|(\mathfrak{t}; \mathfrak{t})$ or $(-\mathfrak{t}; -\mathfrak{t})|(0; -\mathfrak{t})|(\mathfrak{t}; -\mathfrak{t})$ (SC-068-a, L227; SC-068-c, L230; SC-068-d, L233). They remain interpretations of the even strain observable, not recovered senses of rotation. The source’s A twins have negative and B twins positive strain by its convention (SC-098-a, L506).

Clause 0.1a states “Every step is a system-wide settlement” and “Events do not commute.” This manuscript’s P-2 reading places the source’s evolving twins on a boundary-conditioned standing network: excitations migrate along density gradients, lock transversely at nodal channels, and the allowed network changes as the whole configuration settles. The clamps and internal boundary data set the mode geometry; the transition is a global eigenmode snap in that reading. No optimisation objective is supplied by the core, and none is assigned here.

DM-2 repeats the source’s temperature settings on warming from 100 to 300 K (SC-024-b, L93). Use the same reflections, kernel and symmetry decomposition, with independent temperature equilibration at each setting. The conventional account’s first-order-transition hysteresis belongs to its own comparator. The warming leg is its own settlement; its maps are measured separately. Corroboration statement: P-2 supplies a mechanism for this manuscript’s structural reading at the reconstruction precision, while the existing cooling maps are an in-sample identity and corroborate no invariant. A warming map incompatible with the nominated boundary-selected architecture falsifies that particular mechanism reading, not a presumed reversal of cooling.

4 Cone-position translation

P-3 says the load “does not compress the anchors” and is taken by interstitial spacetime whose packing density changes by the negative fractional volume change. Let $\mathfrak{E}_{ij}$ denote the small strain tensor, δ_{ij} the Kronecker tensor, and $\mathfrak{E}_{ij}^{\text{tf}}$ its trace-free part; i, j are spatial indices. The

first-order geometrical identities underlying the I-3a trace and shear split are

$$\frac{\Delta V}{V} = \text{tr } \mathfrak{E} + O(\mathfrak{E}^2), \quad \mathfrak{E}_{ij}^{\text{tf}} = \mathfrak{E}_{ij} - \frac{\delta_{ij}}{3} \text{tr } \mathfrak{E}. \quad (31)$$

This manuscript’s reading treats the source’s strain relative to the aristotype as that interstitial load (SC-107-d, L471). The volume trace changes packing at first order; trace-free orthorhombicity does not. The source’s uniform in-plane and axial modes, in-plane shear, orthorhombic strain and remaining shear components retain their symmetry meanings (SC-107-a, L485; SC-107, L486; SC-107-b, L488; SC-107-c, L489). A mode normalisation is needed before converting amplitudes into a physical stress tensor. The observed strain is not an experimentally established perfect-form stress tensor.

The translation table specifies what a structural statement contributes.

Structural object	FDT reading	Observable boundary
Crystal and twins	This manuscript’s single-pattern reading of 0.1b	Reflections and weighted lattice maps determine the structural dictionary.
Ionic rest content	I-5 closed confinement patterns	Eigenproblem, without an assigned particle address.
Orthorhombic band	This manuscript’s P-2 nodal architecture	Even strain needs DM-1 to distinguish tilt and blur.
Cell-volume change	This manuscript’s P-3 interstitial packing response	Trace measurement; no evaluated local omnium profile.
Octahedral rotation sense	Structural sign	No identification with P-4 circulation or P-5 torsion.
Physical rod twist	P-5 magnetic input	Hand-odd field measured by a separate gradiometer.

P-4’s flow direction is “the cone’s own circulation sense” fixed by its helical geodesics. The source’s alternating structural rotations between layers do not change that intrinsic sense (SC-017, L82; SC-018, L84; SC-027-a, L108). The cited Néel-like ferroelectric walls, where polarisation rotates, likewise supply no physical torsion (SC-061-a, L211; SC-061, L192). This manuscript’s reading of the source’s superconductivity discussion uses P-4’s tip-to-tip overlap of opposite-helicity electron cones and P-2’s shared scattering-free nodal channels (SC-071, L240; SC-071-a, L241; SC-071-b, L242). The source presents no electronic or superconducting measurement of these reconstructed walls (SC-074, L257; SC-082, L259; SC-083, L271).

5 Predictions

DC-3, SA-99, is retired because the core provides no map from its local omnium profile to the measured unit-cell-volume contrast; O-4 names that missing constitutive profile. The remaining blocks are conditional by construction: they nominate a density-coupled observable or a torsion-field dictionary and test the resulting existence statement. An exclusion effect is a specified apparatus test point, not an FDT amplitude.

5.1 Common response and conventional correction

For each isotope pair let $m_{\text{fu,heavy}}$ and $m_{\text{fu,light}}$ denote formula-unit masses and let $\Delta_i \ln \alpha_{\text{ext}}$ denote the compactness increment for isotope channel i . The compactness is obtained from

weighing and support-radius metrology before measuring the response. The exact pair input, and its fixed-geometry rest-content reduction, are

$$\Delta_i \ln \alpha_{\text{ext}} = \ln \frac{\mathcal{M}_{\text{heavy}}/R_{\text{b,heavy}}}{\mathcal{M}_{\text{light}}/R_{\text{b,light}}}, \quad (32)$$

$$\Delta_i \ln \alpha_{\text{ext}}|_{\text{fixed packing}} = \ln \frac{m_{\text{fu,heavy}}}{m_{\text{fu,light}}} = \ln \left(1 + \frac{\Delta m_{\text{fu}}}{m_{\text{fu,light}}} \right). \quad (33)$$

The support radius is the evaluation radius for each weighed specimen; at a common matched radius only its content changes. For geometrically matched volumes the density estimate subtracts $\Delta \ln V_{\text{cell}}$ from the formula-mass logarithm. For unequal spherical supports the full identity adds $2\Delta \ln R_{\text{b}}$ to that density estimate; therefore a measured radius difference is retained, not silently absorbed into the cell-volume correction. This follows from mass being density times volume and volume scaling as the cube of radius. Oxygen-stoichiometry differences enter the measured masses as well as the independent chemical assay. Neither a strain shift nor a width shift determines its own compactness input.

Let $\mathfrak{Q}$ be a positive structural observable and $\mathcal{N}_i$ its conventional logarithmic isotope correction. The corrected shift is $\eta_i = \ln(\mathfrak{Q}_{\text{heavy}}/\mathfrak{Q}_{\text{light}}) - \mathcal{N}_i$. Let S_i be the derivative of the corrected logarithmic observable with respect to logarithmic exterior compactness, at fixed temperature, pressure, shape, packing, composition apart from the isotope, and reconstruction kernel. With $\mathcal{A}$ used solely as the logarithmic integration coordinate in this response integral, the definition and finite response are

$$S_i = \left. \frac{\partial(\ln \mathfrak{Q} - \mathcal{N}_i)}{\partial \ln \alpha_{\text{ext}}} \right|_{\text{fixed controls}}, \quad \eta_i = \int_{\ln \alpha_{\text{ext,light}}}^{\ln \alpha_{\text{ext,heavy}}} S_i(\mathcal{A}) d\mathcal{A}. \quad (34)$$

This is the manuscript's density-coupled equilibrium reading of I-7. A nonzero integral is its existence condition; the positive mass input fixes no observable sign before the sensitivity is established. The integral, not a local derivative times a finite span, is the amplitude.

The conventional comparator U-11 has a mass-independent classical configurational distribution on the Born–Oppenheimer surface at every temperature: the kinetic factor separates from the position distribution. Its isotope dependence is carried by nuclear quantum motion on that surface, beyond-Born–Oppenheimer diagonal and nonadiabatic electron–lattice terms, and nuclear field-shift and hyperfine terms. Compute those terms with the assayed isotope fractions: path-integral or quasi-harmonic nuclear calculations and the corresponding electronic and nuclear-radius or nuclear-moment corrections (U-20). Subtract them before forming any corrected mean. The nuclear zero-point stress is a full tensor, computed mode by mode from mode Grüneisen tensors, the substituted species' share of each mode's kinetic energy, and the derivative of mean mode energy with respect to logarithmic frequency at the measurement temperature. Its observable contribution contracts each stress component with the independently measured derivative of the logarithmic observable with respect to that applied stress component. The orthorhombic contribution is evaluated in each twin's own axes, including its sign change between twins. A uniform imposed orthorhombic stress leaves the twin-mean magnitude and wall thickness unchanged to first order; the wall's own structural stress response is computed separately.

Let $\mathfrak{B}$ be the single-crystal bulk modulus and V_{zp} the cell volume shifted by the hydrostatic zero-point stress alone. Only that part reduces to

$$(\Delta \ln \mathfrak{Q})_{\text{hydro}} = -\mathfrak{B} \left(\frac{\partial \ln \mathfrak{Q}}{\partial P} \right) \Delta \ln V_{\text{zp}}. \quad (35)$$

The stress convention is positive compression; its volume change is negative pressure change divided by bulk modulus. The deviatoric correction and the measured total cell-volume difference are separate quantities.

The fixed-packing benchmarks computed from U-06 and U-12 are

$$\Delta_{\text{Cu}} \ln \alpha_{\text{ext}} = 0.00497 \quad \text{for full copper substitution,} \quad (36)$$

$$\Delta_{\text{O}} \ln \alpha_{\text{ext}} = 0.01977 \quad \text{for full oxygen substitution,} \quad (37)$$

$$\Delta_{\text{O}} \ln \alpha_{\text{ext}} = 0.01781 \quad \text{for oxygen exchange fraction 0.90.} \quad (38)$$

The exchange benchmark is assumed, not a measured exchange fraction (U-18). Every actual compactness input uses Eq. 32 and the characterisation U-19.

5.2 Decision rules and simulation design

Let $\mathcal{K}_{\text{rep}}$ denote the number of independent replication units, $\bar{\mathbf{v}}$ their mean corrected response and $\mathcal{E}_{\text{rep}}^2$ their sample variance. These fraktur statistics do not reuse the clock factor $\mathbf{m}$ or a core scalar. For each control j , let $\hat{\mathcal{B}}_j$ be its estimated signed bias bound, $\mathcal{E}_j^2$ its reading variance, and $\mathcal{K}_j$ its number of readings. The nonnegative weight $\mathcal{W}_j$ converts that bound to the observable's units. Let $\mathcal{V}_{\text{rep}}$ and $\mathcal{V}_j$ be the corresponding estimated variances of the mean and weighted bound; $\mathcal{V}$ is their sum, $\mathfrak{d}$ the Welch–Satterthwaite degrees of freedom, $\mathcal{Z}$ the Student quantile, $\mathcal{P}_{\mathfrak{d}}$ its quantile function and $\mathfrak{H}$ the total threshold. For independent controls the specified criterion is

$$\mathcal{V}_{\text{rep}} = \frac{\mathcal{E}_{\text{rep}}^2}{\mathcal{K}_{\text{rep}}}, \quad \mathcal{V}_j = \frac{\mathcal{W}_j^2 \mathcal{E}_j^2}{\mathcal{K}_j}, \quad \mathcal{V} = \mathcal{V}_{\text{rep}} + \sum_j \mathcal{V}_j, \quad (39)$$

$$\mathfrak{d} = \frac{\mathcal{V}^2}{\mathcal{V}_{\text{rep}}^2/(\mathcal{K}_{\text{rep}} - 1) + \sum_j \mathcal{V}_j^2/(\mathcal{K}_j - 1)}, \quad (40)$$

$$\mathcal{Z} = \mathcal{P}_{\mathfrak{d}}(0.975), \quad \mathfrak{H} = \sum_j \mathcal{W}_j |\hat{\mathcal{B}}_j| + \mathcal{Z} \sqrt{\mathcal{V}}. \quad (41)$$

Here $\mathcal{P}_{\mathfrak{d}}$ is the Student quantile function at the stated degrees of freedom. The probability is the two-sided level U-17. Covariances enter the mean's sample variance before this independent-control combination; correlated control estimates require their covariance terms and their calibrated effective degrees of freedom in the actual experiment. The displayed simulations assume independent control estimates, as U-08 and U-09 specify. The additive magnitudes protect against unresolved bounded bias, while each bound's estimation error enters the variance.

Let $\mathcal{F}_*$ denote the specified exclusion effect. Detection requires $|\bar{\mathbf{v}}| > \mathfrak{H}$ against the zero comparator. Exclusion requires $|\bar{\mathbf{v}} - \mathcal{F}_*| > \mathfrak{H}$ for that specified effect. Attribution requires detection with all of the same bounds and their uncertainties, independent confirmation of the input, and survival of the block's sign or co-variation condition after conventional corrections. A failed control invalidates attribution; it is not removed from the threshold. The effective precision is the complete threshold $\mathfrak{H}$, including bias bounds, not the diffraction resolution. A finite null excludes the named effect through this rule and leaves smaller existence amplitudes untested.

The simulations use 20000 draws, seed 20261025, and a two-sided nominal probability 0.05 (U-17). Each bound has magnitude 0.1, with 10 readings of standard deviation 0.3; its magnitude is estimated as the absolute sample mean (U-15, U-09). For isotope responses the

replication-unit noise is normal with standard deviation 1 (U-08). The zero-bias comparator median of $\mathfrak{H}$ is printed to three significant figures. The exclusion point is twice that rounded median; it is expressed in per-unit standard-deviation design units. The rates below use every true bias at its bound: toward a positive detection for the false-rejection rate, toward the proposed effect for exclusion under the comparator, and against the effect for power at the test point. For a negative effect reverse all bias signs. The binomial standard error uses the simulated probability and the draw count; the resulting simulated coverage assesses this design, not a theorem for arbitrary bias distributions. The threshold's random estimation is retained in every draw.

5.3 T-1: copper-isotope domain strain

DC-1 discriminates SA-91: the source's reconstructed strain maps do not fix whether domain-mean strain has an additional compactness response. The referent is LESCO of the source's composition, grown as matched crystals from one La/Eu/Sr/O feed and one schedule, one enriched in copper-63 and its partner in copper-65 (SC-001, L18; U-19). Anneal alike; assay enrichment by mass spectrometry, weigh each crystal and measure its support radius, cut each pair to a common shape, and map several slices at 300 K by the source's scanning 3DXRD (SC-024-b, L93). The crystal pair is the replication unit; slices and twins are subsamples.

Let $\mathfrak{Q}_{\text{dom}}$ be the mean magnitude of the A- and B-twin peaks of the bimodal strain histogram, retaining their separate signed profiles before taking magnitudes (SC-098, L504; SC-098-a, L506). Let $\mathcal{N}_{\text{Cu}}$ denote the full copper correction just defined. The solved defining condition is

$$\eta_{\text{Cu}} = \ln \frac{\mathfrak{Q}_{\text{dom,heavy}}}{\mathfrak{Q}_{\text{dom,light}}} - \mathcal{N}_{\text{Cu}} = \int_{\ln \alpha_{\text{ext,light}}}^{\ln \alpha_{\text{ext,heavy}}} S_{\text{Cu}}(\mathcal{A}) d\mathcal{A} \neq 0. \quad (42)$$

This manuscript's density-coupled strain reading is conditional by construction on the nonzero integral. Its single FDT channel is the positive I-7 compactness input; its response sign is the integral's sign. Every thermal, pressure, composition and geometry change is inside the controls. The conventional comparator is zero after $\mathcal{N}_{\text{Cu}}$ subtraction (U-11). Besides classical mass independence, copper occupies an inversion centre of the parent structure, so the even parent X-point tilt displaces no copper; other copper quantum motion and all electronic and nuclear corrections remain in $\mathcal{N}_{\text{Cu}}$.

The seven controls are Sr, Eu and O content measured on a piece of each crystal; copper enrichment; correction uncertainty; reference-crystal 3DXRD calibration in each session; and temperature (U-22). The correction uncertainty includes the orthorhombic zero-point stress evaluated twin by twin, not only hydrostatic pressure. A reference crystal is measured in each session; its error is kept in the paired response. Detection, specified-effect exclusion and attribution use Eq. 41 with all seven controls, their estimated errors and eight crystal pairs (U-08, U-15). Attribution additionally requires the independent positive input and an established nonzero response integral of the observed sign.

The derived zero-bias median threshold is $\mathfrak{H}_{\text{Cu}} = 1.69$ and the investigator-chosen test point is $\mathcal{F}_{*,\text{Cu}} = 3.38$ design units. The simulated comparator false-rejection rate is 0.0103 ± 0.0007 , below the nominal level; exclusion probability at that point under the comparator is 0.9822 ± 0.0009 , and power with every bias opposing the effect is 0.9836 ± 0.0009 . These are the simulations of the three specified rules, not an FDT strain magnitude. Ablation replaces the additional response integral by the conventional zero, holding all controls fixed. The test-point difference exceeds this block's median criterion.

5.4 T-2: oxygen substitution and a species-blind contrast

DC-2 discriminates SA-48: a cooling-based strain interpretation leaves the corrected response to a separately controlled oxygen mass increment undetermined. Use natural-copper crystals from the same growth as the copper pairs, cut in pairs, anneal one in oxygen-18 and its partner in oxygen-16 on one schedule, and map them in the copper sessions (U-19). Measure the exchange fraction and depth profile and the post-exchange oxygen stoichiometry; weigh and measure the support radius of each crystal. Match shape and support to the copper pair in its session. Compute $\mathcal{N}_O$ in each voxel at its local exchange fraction and average only after subtraction. The session, not a voxel or a single isotope pair, is the replication unit.

Let η_O be the corrected logarithmic oxygen shift of the domain observable. Define $\mathfrak{C}$ as the division-free contrast of the two increments. The defining equations and their linear species-blind solution are

$$\eta_O = \ln \frac{\Omega_{\text{dom,heavy}}}{\Omega_{\text{dom,light}}} - \mathcal{N}_O = \int_{\ln \alpha_{\text{ext,light}}}^{\ln \alpha_{\text{ext,heavy}}} S_O(\mathcal{A}) d\mathcal{A} \neq 0, \quad (43)$$

$$\mathfrak{C} = (\Delta_O \ln \alpha_{\text{ext}}) \eta_{\text{Cu}} - (\Delta_{\text{Cu}} \ln \alpha_{\text{ext}}) \eta_O = 0. \quad (44)$$

This manuscript's reading treats the corrected log observable as one species-blind function $\mathfrak{r}$ of logarithmic compactness. Its linearity over both intervals and the interval between their bases yields the last equality, with both shifts nonzero. For nonzero input intervals the contrast vanishes if and only if the two secants are equal; the constant-prefactor requirement is the common response function and common calibration. A vanishing contrast also occurs when both isotope shifts vanish. The additional FDT prediction is the nonzero oxygen shift, conditional by construction; the contrast is an extra falsifier of the joint response model. Its single-channel scope is I-7 compactness, with the oxygen observable sign conditional on its sensitivity.

Let $\Delta_{\text{base}} \ln \alpha_{\text{ext}}$ be the logarithmic input of the oxygen-16 base above the copper-63 base. Let u_1, u_2, u_3 be intermediate points in the copper interval, oxygen interval and interval between bases. Taylor's theorem applied at each base and then between the bases gives, for a twice continuously differentiable response, the exact Lagrange remainder

$$\mathfrak{C} = \frac{1}{2} (\Delta_O \ln \alpha_{\text{ext}}) (\Delta_{\text{Cu}} \ln \alpha_{\text{ext}}) [\mathfrak{r}''(u_1) \Delta_{\text{Cu}} \ln \alpha_{\text{ext}} - \mathfrak{r}''(u_2) \Delta_O \ln \alpha_{\text{ext}} - 2\mathfrak{r}''(u_3) \Delta_{\text{base}} \ln \alpha_{\text{ext}}]. \quad (45)$$

There is no numerical bound on this curvature of the response function. Thus an out-of-bounds contrast rejects linearity and species-blindness jointly, without assigning the failure to one alone. At fixed packing the derived base offset is $\Delta_{\text{base}} \ln \alpha_{\text{ext}} = 0.00150$ for full copper-63 enrichment. At 99 percent copper-63 with the remaining copper-65 it is 0.00145 (U-18, U-12). Actual base offsets come from the weighed pairs and measured radii.

The conventional corrected oxygen shift is zero (U-11). Oxygen moves in the tilt mode, so its quantum correction is retained in full, including its measured stress response; it is not transferred from copper. The ten bounded groups retain the seven copper controls with the oxygen correction uncertainty in the correction slot, and add exchange-depth variation, post-exchange stoichiometry and paired-session matching (U-22). Each group bounds the sum of its physical contributions. The mean shift uses eight sessions and all ten groups in every decision rule (U-08, U-15). Attribution requires that the independent positive input and the contrast condition both survive these controls.

For the contrast form the difference within each session before estimating its variance. For correlated shifts its variance is

$$\begin{aligned} \text{Var}(\mathfrak{C}) = & (\Delta_{\text{O}} \ln \alpha_{\text{ext}})^2 \text{Var}(\eta_{\text{Cu}}) + (\Delta_{\text{Cu}} \ln \alpha_{\text{ext}})^2 \text{Var}(\eta_{\text{O}}) \\ & - 2(\Delta_{\text{O}} \ln \alpha_{\text{ext}})(\Delta_{\text{Cu}} \ln \alpha_{\text{ext}}) \text{Cov}(\eta_{\text{Cu}}, \eta_{\text{O}}). \end{aligned} \quad (46)$$

The control weights in Eq. 41 are the absolute oxygen input for each copper bound and the absolute copper input for each oxygen bound. Uncertainty in actual inputs is propagated with their joint covariance and cross terms; the design simulation holds its independently specified inputs fixed. The simulated shared-reference standard deviation is 0.7; each total shift has unit variance, with the remainder independent (U-16). The fixed simulation inputs are 0.00497 and 0.01781, and the linear FDT test function has common secant 300 (U-16). The latter gives nonzero shifts but zero contrast by the defining identity.

The derived oxygen threshold is $\mathfrak{H}_{\text{O}} = 2.09$ and its specified test point is $\mathcal{F}_{*,\text{O}} = 4.18$ design units. Its comparator false-rejection rate is 0.0084 ± 0.0006 , exclusion probability is 0.9896 ± 0.0007 , and adverse-bias power is 0.9883 ± 0.0008 . The contrast has median threshold $\mathfrak{H}_{\text{C}} = 0.0350$ and specified departure $\mathcal{F}_{*,\text{C}} = 0.0700$ in its weighted design units. Its false-rejection rate is 0.0075 ± 0.0006 at the comparator and the same 0.0075 ± 0.0006 at the linear species-blind FDT point, where the contrast's mean is again zero. The contrast departure's exclusion probability is 0.9903 ± 0.0007 and adverse-bias power is 0.9900 ± 0.0007 . All false-rejection rates lie below the nominal probability; their uncertainties are binomial standard errors. Ablation of the oxygen response integral returns the conventional zero; the oxygen exclusion point, not the zero contrast, supplies this block's live test-point difference.

5.5 T-3: physical torsion and a hand-odd field

DC-4 discriminates SA-84: the source's structural heterogeneity does not measure a field established by an imposed physical twist. P-5 states "Imposing a physical twist (torsion, helical geometry) on a material is establishing a magnetic field." This manuscript's reading takes the field along the twist axis and reversing with the hand; the directional reading is conditional by construction. Use a LESCO rod cut along [001] from the source's growth, with independently measured diameter and length, at 300 K (U-24). Clamp one end and impose equal static elastic torsions of opposite hand at the other, inside a magnetic shield. A coaxial axial SQUID gradiometer sits beyond the free end at a measured distance. Read the torsion's shear-strain profile along the rod by scanning 3DXRD; turn the x-ray beam off for the magnetic reads. The geometry and twist magnitude remain independently measured symbolic inputs, not assumed field amplitudes.

Let $\mathfrak{b}_z$ be the axial component of $\mathbf{B}$ at the gradiometer and $\mathfrak{b}_{\text{odd}}$ its hand-odd component. Let $\mathcal{Y}_{\text{twist}}$ denote the magnitude of the twist rate measured from the diffraction profile. The response per mapped twist is $\mathcal{H}_{\text{twist}}$. The defining condition and sign-resolved solution are

$$\mathfrak{b}_{\text{odd}} = \frac{\mathfrak{b}_z(+)-\mathfrak{b}_z(-)}{2}, \quad \mathcal{H}_{\text{twist}} = \frac{\mathfrak{b}_{\text{odd}}}{\mathcal{Y}_{\text{twist}}} \neq 0. \quad (47)$$

No moment kernel is declared, so this is an existence statement without a field magnitude. Its single additional channel is physical torsion under P-5; crystallographic rotation is not substituted for it. The conventional comparator is zero: static torsion is even under time reversal, and no magnetic order, applied field or axial heat or charge current supplies a hand-odd axial field after the controls (U-11).

The rod's absence of magnetic order is tested by zero-field muon spin rotation, requiring no spontaneous precession and no relaxation beyond the nuclear-dipole Kubo–Toyabe form (U-25). Alternating-field demagnetisation precedes every run. Measure residual inclusion remanence by SQUID magnetometry and multiply it by the hand-odd response per unit remanence calibrated after magnetisation along and across [001]. Dilute inclusions below the muon sensitivity remain in this bound. Circumferential remanence can evade that ordinary read and turn into an axial moment under twist through the inverse Wiedemann effect. Bound it using the demagnetised rod's hand-odd signal minus the half-sum after circumferential saturation by opposite-polarity axial current pulses, applied after the final run (U-26).

Measure the susceptibility response at two applied fields and extrapolate to zero; the shield's residual field and the susceptibility change both enter the bound. Run a nonmagnetic dummy rod of identical shape first at the specimen's twist angle and then at its torque. Use a position scan to bound torsion-induced displacement relative to the gradiometer. Electrically isolate the rod and measure its axial temperature profile during each run. The steepest measured gradient times the hand-odd response per unit gradient calibrated with a heater at the free end bounds the thermoelectric signal (U-26). These controls are separate from a drift bound. The ten groups are magnetic order, ordinary remanence, circumferential remanence, residual field, susceptibility response, angle-matched fixture, torque-matched fixture, displacement, heat flow and drift (U-09).

Use hands $+- -+$ and $-+ + -$ in alternating cycles, with the cycle pair as replication unit. There are ten such units (U-09). For the drift calculation let j be the reading index, starting at zero, and $\mathcal{D}_j$ the readout drift; $\mathcal{R}_j$ is a random walk with independent normal increments. Let $\mathcal{Q}_1, \dots, \mathcal{Q}_8$ denote the successive field-per-twist readings. The assumed drift and the unit's signed combination are

$$\mathcal{D}_j = \mathcal{R}_j + 0.4j^2 + 20 \exp(-j/30), \quad (48)$$

$$\bar{\mathbf{v}}_{\text{pair}} = \frac{\mathcal{Q}_1 - \mathcal{Q}_2 - \mathcal{Q}_3 + \mathcal{Q}_4 - \mathcal{Q}_5 + \mathcal{Q}_6 + \mathcal{Q}_7 - \mathcal{Q}_8}{8}. \quad (49)$$

Each raw reading has noise standard deviation $2\sqrt{2}$ and the random-walk step is 0.5 (U-23). The combination cancels constant, linear and quadratic drift; the settling term and random walk remain in the simulated units and in the drift control. No baseline fit is silently applied. The ten controls and their independently estimated errors enter detection, specified-effect exclusion and attribution unchanged. Attribution also requires the measured twist, the hand reversal and every magnetic and thermal control to pass.

The derived median threshold is $\mathfrak{H}_{\text{rod}} = 2.02$ and the specified test point is $\mathcal{F}_{*,\text{rod}} = 4.04$ design units. The comparator false-rejection rate under the full drift is 0.0057 ± 0.0005 , exclusion probability is 0.9907 ± 0.0007 , and adverse-bias power is 0.9917 ± 0.0006 . Ablation replaces the P-5 hand-odd field input by the conventional zero. The specified difference exceeds the median criterion; no numerical field-per-twist coefficient is inferred from it.

5.6 T-4: copper-isotope wall width

DC-5 discriminates SA-37: the source's broad near-zero bands leave their corrected equilibrium width response to mass substitution unmeasured. Use the copper pairs and maps of T-1, with several slices per crystal and both wall orientations represented (U-19, U-21). The referent is the 300 K wall class that DM-1 identifies as extended (SC-035-a, L137; U-10). Let $\mathfrak{Q}_{\text{wall}}$ be its full width at half depth in the magnitude of the signed orthorhombic profile. Deconvolve the

signed profile with a sharp reference edge reconstructed alike before taking its magnitude or measuring the width. Average widths over both orientations within each crystal, then form the crystal-pair logarithmic shift. Let $\mathcal{N}_{\text{Cu,wall}}$ denote its full conventional correction. The defining condition is

$$\eta_{\text{wall}} = \ln \frac{\mathfrak{Q}_{\text{wall,heavy}}}{\mathfrak{Q}_{\text{wall,light}}} - \mathcal{N}_{\text{Cu,wall}} = \int_{\ln \alpha_{\text{ext,light}}}^{\ln \alpha_{\text{ext,heavy}}} S_{\text{wall}}(\mathcal{A}) d\mathcal{A} \neq 0. \quad (50)$$

This manuscript’s density-coupled width reading is conditional by construction on a nonzero integral. The positive compactness increment comes from the weighed mass and measured radius; the width sign remains the sensitivity’s sign. Its single additional channel is I-7 compactness, with other channels bounded.

The conventional comparator is zero after the full wall-specific correction (U-11). Inside the wall the tilt’s wavevectors leave the parent X point; no inversion-parity argument holds copper fixed there. Compute $\mathcal{N}_{\text{Cu,wall}}$ for the wall structure under each twin’s own zero-point stress, including the nuclear-quantum, beyond-Born–Oppenheimer, field-shift and hyperfine terms. The hydrostatic formula alone is not the wall correction. Retain T-1’s composition, enrichment, calibration and temperature bounds, replacing its correction uncertainty by the wall correction uncertainty. An eighth aggregate group bounds the sum of kernel uncertainty, orientation-mixture error and oblique-slice error; each constituent is independently characterised (U-21, U-22). The source places [001] approximately 2 degrees out of the plane (SC-034, L150); each wall’s actual angle enters its geometric correction. Eight crystal pairs, not individual walls, supply the variance (U-08). Detection, exclusion and attribution use all eight groups and their errors. Attribution further requires the extended-wall assignment and the independently fixed compactness increment.

The derived median threshold is $\mathfrak{H}_{\text{wall}} = 1.83$ and the specified test point is $\mathcal{F}_{*,\text{wall}} = 3.66$ design units. The comparator false-rejection rate is 0.0097 ± 0.0007 , exclusion probability is 0.9864 ± 0.0008 , and adverse-bias power is 0.9873 ± 0.0008 . Ablation sets the additional width-response integral to the conventional zero. The test-point difference exceeds the median threshold, while a null excludes only the specified effect by its stated rule.

6 Cross-domain reading

The source compares LESCO with other layered cuprates (SC-080, SC-080-a); its comparisons have different evidential classes. The source writes that the variation of calculated Γ_4^+ strains and, therefore, expected domain sizes “appears to range” from 7×10^{-3} in LESCO to 3×10^{-3} in Tl-2201 all the way down to 3×10^{-4} in Bi-2223 (SC-080-b, L231; SC-080, L233; SC-080-a, L234). It writes that strains in YBCO are typically large, of the order 0.01 (SC-105, L516). These values do not determine a shared sensitivity in Eq. 34. Composition, support and the structural response function all change between compounds. The comparison therefore keeps the strain dictionary and declines to transfer a fitted width or a density-chart position from one material to another.

The source cites TEM measurements on LBCO that estimated the width of the expected tetragonal regions at the wall center to be around 100 Å and neutron diffraction that indicated larger values of a few hundred Å based on superstructure peak broadening (SC-057, L195; SC-058, L198; SC-058-a, L199), and Landau-type free-energy models for LBCO that predict the walls’ central region should adopt LTT-like character rather than revert to the HTT phase

(SC-059, L201). Its cited $\text{Ca}_3\text{Ti}_2\text{O}_7$ walls have widths of 60–100 nm (SC-060, L208; SC-060-a, L209). These are cited or simulated comparisons, not additional measurements of the LESCO slice. Each width, strain and correlation length this section takes from outside the source’s maps is a profile-weighted mean under its own probe’s weight (I-3), never under the source’s reconstruction kernel: the LBCO widths under the TEM measurements and under neutron diffraction’s superstructure peak broadening, the $\text{Ca}_3\text{Ti}_2\text{O}_7$ ferroelastic wall widths under infrared nanospectroscopy, and the calculated Γ_4^+ strains other than LESCO’s, the strains in YBCO and the correlation length associated with SC and CDW order parameters under probes the source does not name. For the calculated strain in LESCO the source names no reference and no probe. The source says its minor-mode histograms can be well modelled by a single pseudo-Voigt distribution, without fit parameters specified here (SC-100, L515). It writes that the magnitude of the spatial variations of $\Gamma_5^+(\text{b})$ remains roughly three times smaller than that of Γ_4^+ , the dominant orthorhombic strain (SC-097, L500; SC-097-a, L502). Neither fit nor magnitude comparison is a new constitutive law.

For the electronic comparison the source writes that the correlation length associated with SC and CDW order parameters “is in the region of 2–15 nm in cuprates” (SC-075, L261; SC-075-c, L260). The authors therefore anticipate that the domain-wall symmetry breaking shapes the competition rather than being shaped by it (SC-075-a, L263; SC-075-b, L264). This is an anticipated causal reading attached to cited lengths, not an electronic measurement of the reconstructed walls. The FDT settlement reading couples the whole configuration at each step; it supplies no one-way electronic chronology from those lengths. Corroboration statement: I-7 unifies content channels and P-2 supplies the nominated architecture mechanism, but these cross-material comparisons are cited inputs and corroborate neither invariant. An independently corrected isotope response with the wrong co-variation would falsify the joint density-response reading; the cited width scales alone test no such relation.

7 System-level reading (exploratory)

Scope: one in-sample re-description of the source’s reconstructed structures; no held-out prediction or new numerical parameter is introduced in this section.

X-1: two settled microstructures. The observable is the change from broad near-zero orthorhombic bands at 300 K to fine orthorhombic stripes at 100 K (SC-035-a, L137; SC-063-a, L197). Its defining condition is a weighted strain map with approximately 150 nm bands and 0.5–2 μm separations in the first state, and 100–200 nm features in the second (SC-036, L141; SC-063, L200). The comparator is the source’s same reflection, kernel and symmetry reconstruction, which returns those maps. This manuscript’s P-2 reading treats the broad walls as boundary-selected nodal support and the lower-temperature stripes as the architecture of a different globally settled network. Excitations follow gradients and lock transversely along the channels permitted by those boundaries; the transition changes the joint network rather than prescribing an isolated local reaction. The two maps define the reading’s referent, not a fitted density coordinate.

Guards. Every numerical value here is an in-sample re-description. The strain is even in tilt and remains probe weighted; neither tilt sense nor a unique wall-centre structure follows without DM-1. The cooling leg fixes no warming map. No chart position, thermal compactness

direction, field from structural rotation or local omnium density is inferred. The observable is excluded from the prediction count.

8 Convergence statement

FDT is a true extension of general relativity and quantum mechanics. For the same source and data the I-3 curvature is general relativity's, while I-4's L2 recovery is its weak-field, slow-motion expansion with corrections of order compactness and squared speed divided by squared strand rate. The exact L1 pair reduction is Eq. 18; L3 remains a source programme, not an assertion of exact agreement for every system. The optical face and the lapse reading give the distinct stroke and slow-pattern readings of the same geometry. The instrument reconstruction uses the source's own inputs and dictionary; its limiting map is the identity with every additional constitutive input set to its conventional value. Thus the same reflections, centering filters, reconstruction and symmetry-mode decomposition return the same maps and histograms. This identity corroborates no invariant; containment belongs to I-3's shared stress tensor and to I-4's stated expansion order.

In that map the source's reconstructed temperature sequence, near-zero bands and stripe widths retain their classes and values from the observation map. The 150 nm and 0.5–2 μm dimensions remain supplement-reported (SC-036, L141); the spatial resolution remains supplement-based, at least 70 nm (SC-093, L188). The cited 10^{-4} and experiment-determined 2×10^{-4} strain resolutions remain distinct (SC-045, L169; SC-093-a, L188). The approximate 160 K transition and the map bracket between 140 and 120 K remain separate statements (SC-021, L86; SC-047, L120; SC-050, L132). The cited comparison lengths, calculated strain scales, simulated boundary argument and fitted histogram keep their classes; feeding any one back into its own reconstruction adds no corroboration.

The standard account reads the ions of the source's structure as distinct things, its "A-site cation" (SC-026, L106) and the ions of its "anion migration" (SC-083, L271) among them (SA-26). FDT reads the ions and their crystal as omnium patterns, the single-crystal support reading being this manuscript's application of 0.1b and I-5, while retaining the structural data.

The source writes that its fine stripelike orthorhombic features (SC-063, L200) "may be interpreted as nanoscale inclusions of the LTO phase embedded within the LTT matrix, likely forming to minimize the elastic energy associated with antiphase boundaries" (SC-064, L201; SC-064-b, L202; SC-064-a, L203; SC-064-c, L204; SA-64). FDT reads the change as a system-wide settlement with no objective named by the core (0.1a); this manuscript's boundary-selected nodal reading recovers the same strain maps.

The source asks: "should we consider these extensive heterogeneities as distinct coexisting phases, or instead hold a more holistic view of material structure in which the interplay of continuous and discrete structural variations governs macroscopic properties?" (SC-087-a, L297; SC-087, L298; SC-087-b, L299; SA-87). FDT reads one omnium pattern with its own support and boundary data (0.1b), this manuscript's application to the crystal, while retaining every reconstructed heterogeneity.

The prospective divergence enters only through the added density-response constitutive input or the P-5 twist source. A chart, a branch tag and the conventional diffraction dictionary alone produce no divergence. Ablation of those inputs restores the corrected isotope and torsion comparators exactly.

9 Status ledger

The following table states the obligations and statuses used in this analysis. The response integrals are conditional constitutive readings, not evaluated kernels.

Item	Status and obligation
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 $\rho_{\text{loc}}(r_f)$ from the omnium constitutive law with boundary, surface and core data, reducing to the measured nuclear profile.
O-8	Owed: the constitutive derivation of effective speed c_{eff} and cone index n_{cone} and its reconciliation with lensing; the cone index is posited.
O-9	Owed: the confinement operator D , its domains, boundary data and spectrum; every mass ratio, including the two held-out targets. No mass ratio is evaluated here.
A-3, A-4, A-5	Provisional tokens, open range only, no numerical assignment; their distinct applications are fixed in the chart inventory.
T-1	Prospective; conditional by construction, single I-7 compactness channel; conventional corrected shift zero.
T-2	Prospective; conditional by construction, single I-7 compactness channel; conventional corrected shift zero. Contrast zero for the linear species-blind response and also for the all-null comparator.
T-3	Prospective; conditional by construction, single P-5 twist channel; conventional hand-odd field zero. P-5: “Quantitative twist $\rightarrow$ moment forms are derived in-manuscript through I-1/I-2 with a declared kernel.” No kernel is declared here.
T-4	Prospective; conditional by construction, single I-7 compactness channel; conventional corrected width shift zero.
Structural reading	In-sample: the nodal-architecture reading of the two microstructures; no independent corroboration or counted prediction.

10 Conclusions

The source determines a rich, probe-weighted structural landscape. Its even orthorhombic strain does not alone resolve a wall’s tilt amplitude, rotation and instrumental broadening, and its cooling maps define only the cooling leg. The convergent reflection and warming measurements resolve those structural ambiguities within the source’s own dictionary. This manuscript’s FDT reading places the crystal, twins and walls in one boundary-conditioned pattern whose architecture settles globally. The constitutive tests separate that reading from a repeated structural reconstruction: independently weighed isotope inputs test corrected equilibrium responses, and a mapped physical torsion tests a hand-odd field with magnetic and thermal controls. The sign of the mass input is fixed; the signs of strain and width follow their response integrals. The nominated exclusion effects express experimental reach, not a computed FDT magnitude. The local-volume profile candidate remains outside the predictions because its constitutive map is absent.

References

- [1] E. Ladbrook, J. P. Wright and M. S. Senn, “Giant Domain Walls and Intrinsic Heterogeneity in 214 Cuprate Superconductors,” *Physical Review Letters* **137**, 126504 (2026). DOI: 10.1103/r62x-kt5j.
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