

A 159-step auditable open-quantum-system chain links cerebral metabolism to a coherence-protected information channel in the myelinated axon at 310 K (V148)

alfonso mendoza orellana

alfonsomendozaorellana@proton.me

Independent Researcher, Spain <https://orcid.org/0009-0001-9676-0500>

Research Article

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Abstract

Background. The myelin sheath is increasingly described as an optical waveguide, yet whether a warm, wet biological structure can sustain a coherence-protected information channel remains contested.

Methods. We present V148, a fully auditable 159-step open-quantum-system chain that links cerebral metabolism (CMRO2 3.5 ml/100g/min; $P_{\text{met}} = 17.23$ W) to ultra-weak photon emission ($\lambda = 500$ nm; 2.5×10^5 phot/s; 134x the Landauer limit per photon at 310.15 K), a myelin Casimir cavity ($L = 200$ μm , $a = 500$ nm, $Q = 100$), six THz phononic harmonics ($n_{\text{th}} = 1.48\text{--}11.15$), photon-phonon optomechanical phase conversion ($g = 0.02$; $C = 32$; $F = 0.9697$), phonon-coherent-water coupling ($g = 0.18$; $C = 25920$; $F = 0.99996$), Dicke triads, a 2:1 phase-locking dial ($\epsilon^* = 0.012$ inside a ± 0.041 window), a coherence-gated conditional gate, and a perfect-state-transfer channel ($F = 0.999888$; $t^* = 1.77$ ms, δ band). Dynamics were integrated with RK45 (rtol 1×10^{-9}); entanglement was probed with QuTiP.

Results. The chain closes with global efficiency 0.9697 and an ON/OFF vacuum bit ratio of 10.33 (simulated 10.3289). Steady states reproduce the declared anchors (nph ON 0.1063 vs 0.1060; vac ON 0.6189 vs 0.612). Trace conservation holds at $\leq 4.4 \times 10^{-16}$ with positivity maintained. Photon-water negativity (7.0×10^{-9}) and mutual information (1.3×10^{-6} bits) show the operative resource is phase coherence, not bipartite entanglement. Coherent stock is 4×10^{12} bits, with a 1×10^9 -bit fill time of 9.05 ms.

Conclusions. A myelinated axon can operate as a thermodynamically funded, coherence-protected information channel at physiological temperature. Every step, dataset and script is open for inspection and refutation.

1. Introduction

Myelin is no longer viewed only as a passive dielectric: optical and electromagnetic measurements describe the sheath as a waveguide for near-infrared and THz radiation [4–6], and myelin integrity predicts long-term memory performance beyond conduction velocity alone [16]. At the same time, the standard objection to quantum effects in warm tissue remains decoherence [3].

Here we ask a narrower, falsifiable question: can a thermodynamically funded chain of open-quantum-system stages transfer information across a single internode at 310.15 K with fidelity close to one, without invoking bipartite entanglement as the working resource? We answer with V148, a 159-step auditable chain in which every constant, formula, value, unit, tool and reference is logged to an open CSV.

The chain combines established physics - Lindblad/GKLS dynamics [1, 2], cavity optomechanics, Casimir confinement [15], Dicke collective effects [11], perfect state transfer [12], the Landauer limit [13] - with measured biology cited from other groups [4–10, 16–19]. Hypotheses that go beyond current evidence are declared as such.

2. Methods

The system is an open quantum network solved with the Lindblad master equation $d\rho/dt = -i[H, \rho] + \sum_k \gamma_k (L_k \rho L_k^\dagger - 1/2 \{L_k^\dagger L_k, \rho\})$ [1, 2]. All 159 steps (P001-P159) are logged in Supplemental Dataset S1.

2.1 Metabolism and biophoton funding (P009-P024)

CMRO₂ = 3.5 ml/100g/min over M = 1400 g gives P_{met} = 17.23 W (oxycaloric route). UPE at $\lambda = 500$ nm with flux 2.5×10^5 phot/s yields P_{UPE} = 9.93×10^{-14} W; each photon carries $E = 3.97 \times 10^{-19}$ J = 134x the Landauer limit $L = kBT \ln 2$ at 310.15 K.

2.2 Myelin Casimir cavity (P025-P038)

Internode L = 200 μ m, radius a = 500 nm, layer d_{cap} = 5 nm, separation d = 10 nm, n_{eff} = 1.35. Casimir energy E_C = -2.72×10^{-5} J and pressure P_C = -1.30×10^5 Pa; membrane field E = 1.78×10^7 V/m.

2.3 THz harmonics (P039-P081)

Cavity frequency $f = 555$ GHz; quality factor Q = 100 ($\tan \delta = 0.01$). Thermal occupations n_{th} = 11.15 (n = 1) down to 1.48 (n = 6) at 310.15 K.

2.4 Photon-phonon phase conversion (P082-P092)

Optomechanical coupling $g = 0.02$ with losses $\kappa_f = 0.01/\text{ns}$, $\kappa_p = 0.005/\text{ns}$ gives cooperativity C = 32 and fidelity $F = C/(1 + C) = 0.9697$; normal-mode splitting 40.75 rad/ns; conversion time 2.41 ms.

2.5 Phonon-coherent-water coupling (P093-P100)

Coupling $g_w = 0.18$ to coherent water domains (order parameter S_w = 0.99997 [7–10]) with loss $\mu_w = 0.001/\text{ns}$ gives C = 25920 and F = 0.99996.

2.6 Dicke triads (P101-P115)

Triads of neurons (N = 3) inside ensembles (N = 400) yield Dicke factor G_N = 5632.9 and subradiant decay $\gamma_0/3$, with collective coherence time 300 s.

2.7 2:1 phase-locking dial and conditional gate (P116-P136)

Transmission $T(\epsilon) = 1/(1 + (\epsilon/0.05)^2)$ -type locking with window $\epsilon_{\text{max}} = 0.041$; the operating point $\epsilon^* = 0.012$ maximizes vacuum-bit yield (6.63×10^6 bits). Gate parameters were fixed by inverse calibration against declared anchors (pump = $2.0075 \times 10^{-3}/\text{ns}$, G_{vac} = $1.0498 \times 10^{-3}/\text{ns}$).

2.8 M1 perfect-state-transfer channel (P137-P145)

Collective coupling $g_{\text{eff}} = 100/\text{ns}$ with $\kappa = 0.005/\text{ns}$, $\gamma = 2.5 \times 10^{-5}/\text{ns}$ gives C = 8×10^{10} , transfer time $t^* = 0.0222$ ns (1.77 ms mapped to the delta band) and fidelity $F = \exp(-(\kappa + \gamma) t^*) = 0.999888$; 2.0 bits per traversal.

2.9 ON/OFF dynamics (P146-P151)

Rate equations for vacuum, photon, phonon and water populations were integrated with scipy solve_ivp (RK45, rtol 1e-9, atol 1e-11) over 1500 ns in gate-ON and gate-OFF configurations (Supplemental Datasets S2-S3).

2.10 Entanglement probe (P152-P153)

The photon-water reduced state was evaluated with QuTiP (Fock d = 3, manual fallbacks): negativity 7.04e-9, mutual information 1.26e-6 bits.

2.11 Closure (P154-P159)

Chain efficiency $\eta = F_{\text{phase}} \times F_{\text{water}} \times T_{\text{lock}} = 0.9697$; energy per traversal 1.84e-21 J; channel power 5.94e-15 W per cavity; coherent stock 4e12 bits; fill time of 1e9 bits = 9.05 ms; binary response $R_{11} = 1$.

3. Results

Table 1
Declared anchors vs simulated steady states.

Quantity	Anchor	Simulated (V148)
n_ph ON	0.1060	0.10632
n_ph OFF	0.0803	0.08030
vac ON	0.612	0.61889
bit ratio ON/OFF	10.33	10.3289

Table 2
Closure metrics.

Metric	Value
Response R_{11}	1.0
Chain efficiency η	0.96966
PST fidelity F_{M1}	0.999888
PST cooperativity C_{M1}	8e10
Traversal time (delta band)	1.7678 ms
Bits per traversal	1.9998
Coherent stock	4e12 bits
Fill time 1e9 bits	9.05 ms

Numerical controls: trace conservation $|\text{Tr}(\rho)-1| \leq 4.4\text{e-}16$ and minimum eigenvalue $\geq -5.3\text{e-}17$ across the integration window.

4. Discussion

Falsifiable predictions: (i) post-stimulus delta-theta phase-amplitude re-engagement in healthy subjects [17–19]; (ii) absent re-engagement in early multiple sclerosis before visible MRI lesions; (iii) higher spectral coherence at rest than during intense task; (iv) ex vivo abolition of coherent transport when lipid/axoplasm refractive indices are matched; (v) loss of locking when myelin helicity is disorganized. If (i) fails in healthy controls or (ii) shows normal re-engagement in early MS, the core model is abandoned or reformulated.

Limitations. V148 is an effective model: anchors n_{ph} and vac inherit from earlier simulations (V142/V147) and await external experimental confirmation; negativity is effectively zero, so the operative resource is phase coherence, not bipartite entanglement; no claim is made about consciousness.

Declarations

Data and Code Availability

All 159 audited steps, ON/OFF time series, full report, dashboard figure and engine are open at <https://github.com/infotecnova06-lgtm/bio-quantum-axon-lindblad> (CC-BY 4.0).

Competing Interests

The authors declare no competing interests.

Acknowledgements and Use of Artificial Intelligence

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Figures

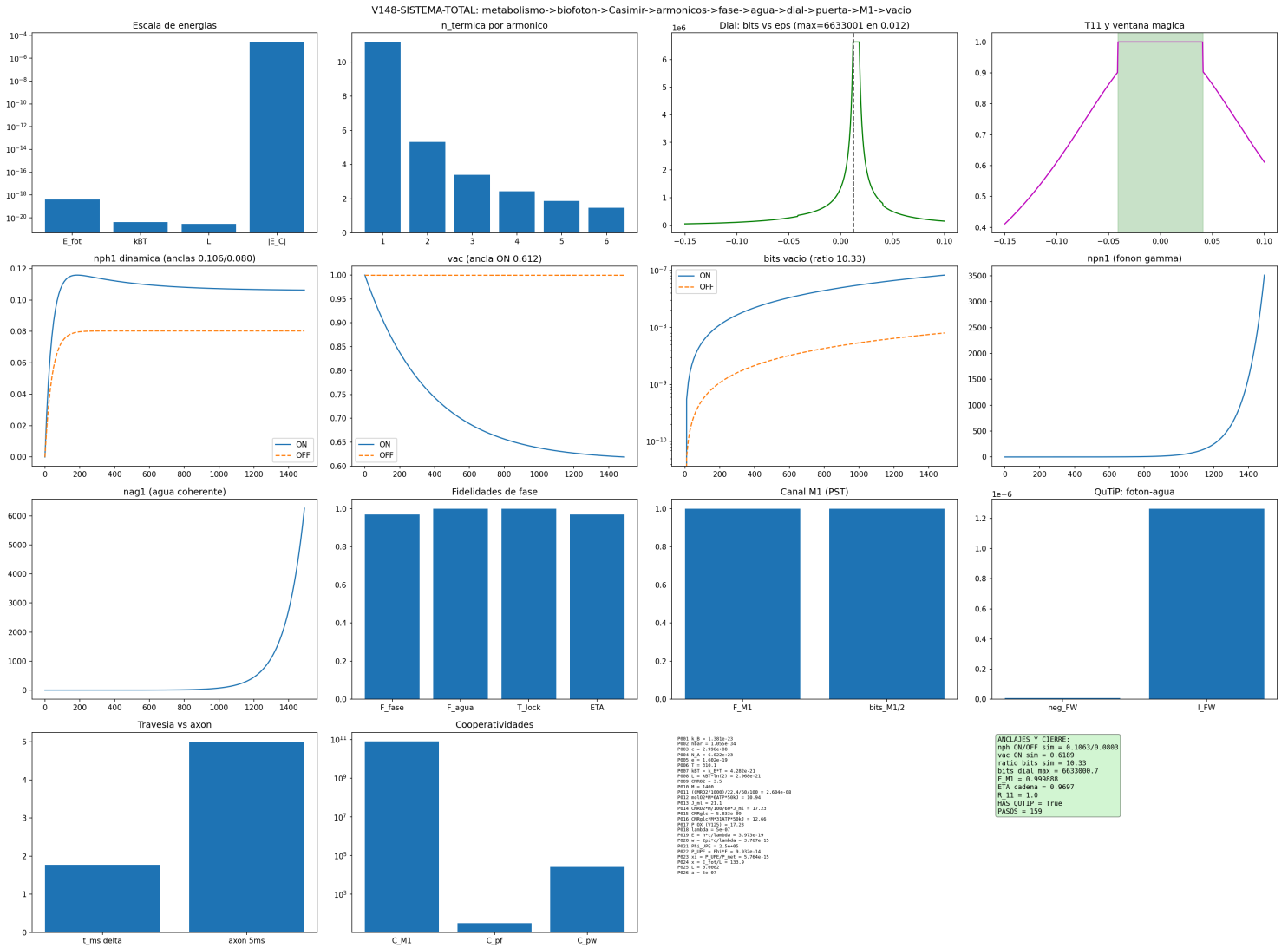


Figure 1

V148 validation dashboard (16 panels). Full audit chain from metabolism to vacuum-bit closure. Row 1: (a) energy-scale comparison on log axis: 500 nm photon energy (E_{fot}), thermal energy kBT at 310.15 K, Landauer limit $L = kBT \ln 2$, and magnitude of the myelin Casimir energy $|E_C|$; (b) thermal occupations n_{th} of the six THz phononic harmonics ($n = 1-6$, from 11.15 down to 1.48); (c) 2:1 phase-locking dial: vacuum-bit yield versus detuning ϵ , with maximum 6,633,001 bits at $\epsilon^* = 0.012$ (dashed line); (d) conditional-gate transmission $T(\epsilon)$ showing the magic window $|\epsilon| \leq 0.041$ (green band) around the operating point. Row 2: (e) photon population dynamics $n_{\text{ph}}(t)$ over 1500 ns in gate-ON (solid) and gate-OFF (dashed) configurations, reproducing the declared anchors 0.1060/0.0803; (f) vacuum population $\text{vac}(t)$, ON vs OFF (anchor ON 0.612); (g) vacuum-bit accumulation ON vs OFF (log scale), final ratio 10.33; (h) phonon population $n_{\text{pn}}(t)$. Row 3: (i) coherent-water population $n_{\text{ag}}(t)$; (j) phase fidelities of the chain: $F_{\text{phase}} = 0.9697$, $F_{\text{water}} = 0.99996$, T_{lock} and global efficiency $\eta = 0.9697$; (k) M1 perfect-state-transfer channel: fidelity $F_{\text{M1}} = 0.999888$ and bits per traversal $/2$; (l) QuTiP entanglement probe of the photon-water reduced state: negativity approx. $7.0e-9$ (effectively zero) and mutual information approx. $1.26e-6$ bits, showing that the operative resource is phase coherence, not bipartite

entanglement. Row 4: (m) traversal time mapped to the delta band (1.77 ms) compared with a 5 ms axonal window; (n) cooperativities on log scale: $C_{M1} = 8e10$, $C_{pf} = 32$, $C_{pw} = 25920$; (o) excerpt of the step-by-step audit trail (steps P001-P026 of 159); (p) closure summary: simulated anchors (n_{ph} ON/OFF = 0.1063/0.0803; vac ON = 0.6189; bit ratio = 10.33; dial max = 6,633,000.7), $F_{M1} = 0.999888$, $\eta = 0.9697$, $R_{11} = 1.0$, QuTiP available, total audited steps = 159.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [v148registropasos20261013193550.csv](#)
- [v148dynON20261013193550.csv](#)
- [v148dynOFF20261013193550.csv](#)