

Geometric Quantization of Molecular Quantum Transport: The CohBit Chrysene Architecture for Ambient-Temperature Quantum-Classical Transduction

Charles D. Schaper, Ph.D.

Chief Editor, *Annals of the Chrysene Formalism*
San Francisco, California, USA
editor@chrysene.com

Abstract

The construction of macroscopic single-molecule architectures that combine coherent quantum transport with classical control remains limited by two thermodynamic obstacles: stochastic self-assembly in continuous manifolds and rapid thermal decoherence at ambient temperature. This work introduces the CohBit architecture, in which dual-channel molecular quantum transport is formalized by geometric quantization on a discrete, non-commutative manifold—the Chrysene Instantiation Space $\mathcal{I}_C$ —canonically identified with the integer lattice $\mathbb{Z}^3$.

A 3, 6, 9, 12-tetrasubstituted chrysene core is taken as the elementary geometric basis tensor. Its C_{2h} symmetry, together with hard Dirichlet boundaries at every $sp^2 \rightarrow sp^3$ termination, yields an algebraic Zero-Divisor Theorem that enforces strict orthogonality between longitudinal ballistic data channels and transverse electrostatic control channels. The principal logic operation is resonant Stark tuning of molecular orbitals; persistent ring currents on the aromatic perimeter supply secondary geometric phases and topologically protected molecular flux degrees of freedom. Vertical co-facial stacking produces bipartite dimers that realize single-electron Coulomb blockade and memristive hysteresis whose thermodynamic cost is bounded from below by the Landauer limit.

Supramolecular polymerization of these nodes via conjugated polyene bridges generates an orthogonal crossbar that functions as a field-programmable neural array supporting native four-quadrant analog matrix multiplication. Thermal decoherence is controlled by a hierarchy of mechanisms: C_{2h} Fröhlich selection rules, acoustic reflection at Ricci-curvature singularities, Anderson localization of phonons inside an interstitial α -helical scaffold, and irreversible dissipation into a Caldeira–Leggett continuum. Under these mechanisms the effective electron-phonon coupling is driven toward zero, furnishing a theoretical lower bound on phase-coherence time compatible with ballistic transit at ambient temperature.

The resulting construction supplies a coherent algebraic and open-system framework for ambient-temperature quantum-classical transduction. Quantitative first-principles parameters, realistic geometric-phase magnitudes, and experimental realization of the interstitial scaffold remain open problems that must be addressed before the architecture can be regarded as a physical blueprint.

Keywords: Chrysene Instantiation Space, CohBit Architecture, Quantum-Classical Transduction, Discrete Non-Commutative Geometry, Field-Programmable Neural Array, Stark Tuning, Electron-Phonon Coupling, Ambient-Temperature Coherence, Molecular Quantum Transport

1 Introduction: The Geometric Evolution of Molecular Electronics

Contemporary attempts to realize single-molecule devices, ballistic quantum wires, and molecular quantum-dot cellular automata have been formulated almost exclusively within the category of continuous, differentiable Euclidean manifolds $\mathbb{R}^n$. While

this framework furnished the initial conceptual escape from the dynamic power-dissipation bounds of silicon CMOS, two fundamental obstructions arise when the continuous model is scaled to macroscopic, deterministic architectures.

1. **The Supramolecular Assembly Obstruction.** In an unbounded continuous metric space the free-energy landscape is governed by probabilistic thermodynamic funnels. Con-

sequently, the construction of a defect-free, high-density crossbar array reduces to a stochastic self-assembly problem. Geometric phase slips and spatially non-uniform orbital overlaps appear as unavoidable variance in the macroscopic routing of coherent wave-packets.

2. **The Thermal Deherence Obstruction.** Preservation of the electronic phase-coherence time τ_ϕ at ambient temperature requires that the electronic Hamiltonian H_e be effectively decoupled from the low-frequency acoustic modes of the environmental phonon bath H_{ph} . In an unconstrained continuous molecular system the electron-phonon coupling remains finite; as $T \rightarrow 300$ K inelastic scattering drives the wave-packet into the classical diffusive regime.

Both obstructions are intrinsic to the continuous category: they cannot be removed by any local refinement of potentials or dielectric profiles that remain defined over $\mathbb{R}^n$.

1.1 Geometric Quantization in the Chrysene Instantiation Space $\mathcal{I}_C$

The present work replaces the continuous ambient category by a discrete, non-commutative fibrated manifold—the Chrysene Instantiation Space $\mathcal{I}_C$ —mapped strictly onto the integer lattice $\mathbb{Z}^3$.

The foundational computational object is the 3,6,9,12-tetrasubstituted chrysene core, regarded as a geometric basis tensor Ψ_C . Its rigid C_{2h} point-group symmetry, together with the hard Dirichlet boundary realized at every $sp^2 \rightarrow sp^3$ affine termination, imposes exact algebraic boundary conditions on the molecular assembly. Continuous fractional geometries are thereby excluded; every admissible localization of a coherent wave-packet is forced onto an integer lattice point.

Within this discrete topology the longitudinal (C6–C12) and transverse (C3–C9) transport channels become strictly orthogonal. The resulting algebraic Zero-Divisor Theorem guarantees that the geometric coupling between the two channels vanishes identically, elevating channel isolation from an approximate geometric observation to a topological identity on $\mathcal{I}_C$.

The same discrete lattice admits a natural interstitial metamaterial: the volumetric voids of the chrysene crossbar are employed as templates for the in-situ condensation of rigid α -helical polypeptides. These polypeptides function simultaneously as

- a source of strong diagonal disorder that drives Anderson localization of acoustic phonons ($\xi \rightarrow 0$),
- a continuous Caldeira–Leggett bath of infinite spectral density whose Poincaré recurrence time diverges, and
- a non-Markovian structural damper that renormalizes the effective electron-phonon coupling constant to the trivial fixed point $\lambda_{eff} \rightarrow 0$.

The composite mechanism— C_{2h} Fröhlich selection rules, Ricci-curvature impedance mismatch at the $sp^2 \rightarrow sp^3$ boundary, Anderson localization, and irreversible Caldeira–Leggett dissipation—bounds the decoherence rate sufficiently to preserve ballistic phase coherence at ambient temperature.

The resulting architecture realizes a high-fidelity quantum-to-classical transducer. Transient quantum phenomena (resonant Stark-effect tunneling and coherent ballistic conduction) are exploited for non-linear operations; the output is then deterministically projected onto stable, measurable classical states. Persistent aromatic ring currents on the molecular perimeter furnish auxiliary molecular flux qubits that enable non-destructive magnetic-dipole parity monitoring, while the dominant logic gating is performed by the electrostatic Stark-Veto.

1.2 Scope of the Work

The manuscript develops the CohBit architecture as a fully rigorous algebraic and physical theory, proceeding according to the following plan.

- **Section II** constructs the axiomatic topology of the discrete manifold $\mathcal{I}_C$. The Zero-Divisor Theorem is proved by combining the C_{2h} symmetry of the basis tensor with the hard Dirichlet conditions imposed by the $sp^2 \rightarrow sp^3$ terminations and the associated Ricci-curvature singularities.
- **Section III** derives the quantum transport mechanics on a single tensor: one-dimensional dielectric confinement, the resonant Stark Tuning Operator, and the secondary role of persistent ring currents as molecular flux qubits for non-destructive parity readout.
- **Section IV** extends the construction to the bipartite (co-facial) dimer, establishing single-electron charge quantization, Coulomb blockade, and the Landauer–Stark thermodynamic bounds on memristive hysteresis.
- **Section V** scales the elementary nodes to a macroscopic orthogonal crossbar, proving native four-quadrant analog matrix multiplication and the field-programmable character of the resulting neural array.
- **Section VI** supplies the complete physical derivation of ambient-temperature coherence: Fröhlich selection rules, Ricci-curvature reflection, Anderson localization of interstitial phonons, Caldeira–Leggett dissipation, and the renormalization-group flow of λ_{eff} to zero.
- **Section VII** reports computational electronic-design-automation emulations that corroborate the Quantum-Confinement Stark-Effect veto surface, sub-femtosecond transient switching, and the percolation threshold for fault-tolerant routing under stochastic defects.

The development is throughout axiomatic: every physical claim is reduced to a precise algebraic identity or a theorem on the discrete manifold $\mathcal{I}_C$.

2 Axiomatic Topology of the Single-Molecule CohBit

To transcend the topological and thermodynamic limitations inherent in continuous molecular electronics, the computational architecture is transferred from the differentiable Euclidean manifold $\mathbb{R}^n$ into a strictly quantized algebraic space. This section constructs the fundamental geometry of the single-molecule CohBit by defining the discrete operational boundaries of the Chrysene Instantiation Space $\mathcal{I}_C$.

2.1 The Fibrated Base Manifold and the Chrysene Ring $\mathcal{R}_C$

Let the geometric foundation of the architecture be a discrete, fibrated three-dimensional base manifold $\mathcal{M}$, canonically identified with the integer lattice $\mathbb{Z}^3$ and evaluated over the finite field $\text{GF}(4)$. Restriction of the physical coordinate space to this lattice imposes rigid Dirichlet boundary conditions and thereby excludes all continuous fractional geometries and Markovian random walks that characterize stochastic self-assembly in $\mathbb{R}^n$.

The elementary computational object occupying $\mathcal{M}$ is the 3, 6, 9, 12-tetrasubstituted chrysene monomer. Within $\mathcal{I}_C$ this molecule is abstracted as a geometric basis tensor Ψ_C .

Definition 1 (Chrysene Basis Tensor). *A valid tensor in the discrete instantiation space $\mathcal{I}_C$ is the ordered pair*

$$\Psi_C = (\vec{v}_C, c_C),$$

where $\vec{v}_C \in \text{GF}(4)^n$ is the spatial connectivity vector that encodes the admissible electronic transport pathways on the lattice, and $c_C \in \mathbb{R}^+$ is the absolute scalar capacity that realizes the steric and dielectric Dirichlet boundary condition at every $\text{sp}^2 \rightarrow \text{sp}^3$ termination.

Definition 2 (Non-Commutative Chrysene Ring). *The non-commutative Chrysene Ring is the algebraic structure*

$$\mathcal{R}_C = (\mathcal{I}_C, \oplus, \otimes).$$

The primary binary operation $\otimes$ (Geometric Coupling) is defined by means of the continuous metric projection $\nu : \text{GF}(4)^n \rightarrow \mathbb{R}^n$ and an asymmetric bilinear form W_{bay} induced by the anisotropic steric potential of the molecular core:

$$\gamma_{AB} = \frac{\nu(\vec{v}_A)^\top W_{\text{bay}} \nu(\vec{v}_B)}{\|\nu(\vec{v}_A)\|_2 \|\nu(\vec{v}_B)\|_2}.$$

Since $W_{\text{bay}} \neq W_{\text{bay}}^\top$, the product is non-commutative:

$$\Psi_A \otimes \Psi_B \neq \Psi_B \otimes \Psi_A.$$

The hard Dirichlet boundary realized at each $\text{sp}^2 \rightarrow \text{sp}^3$ affine connection further generates a discontinuous gradient in the discrete combinatorial Ricci curvature. This gradient acts as an infinite impedance mismatch that maps every continuous leakage path into the Null Ideal $\mathcal{I}_0$.

2.2 The Zero-Divisor Theorem and Channel Orthogonality

Dual-channel operation of the CohBit requires the simultaneous, non-interfering coexistence of two independent signal pathways: the longitudinal Data Channel (C6–C12 axis) and the transverse Control Channel (C3–C9 axis). Within the ring $\mathcal{R}_C$ this mutual isolation is expressed by the existence of geometric zero divisors.

Theorem 1 (Algebraic Zero-Divisor Theorem). *Let Ψ_{SD} be the Source-Drain basis tensor of the longitudinal Data Channel and Ψ_G the Gate basis tensor of the transverse Control Channel. If the corresponding connectivity vectors are orthogonal,*

$$\vec{v}_{\text{SD}} \cdot \vec{v}_G = 0,$$

then their Geometric Coupling evaluates identically to the Null Tensor:

$$\Psi_{\text{SD}} \otimes \Psi_G = \Psi_0.$$

Consequently the two channels are algebraically decoupled on $\mathcal{I}_C$.

Proof. The C_{2h} point-group symmetry of the rigid polycyclic core forces the vectors $\vec{v}_{\text{SD}}$ and $\vec{v}_G$ into a cruciform geometry. Under the continuous metric projection the bilinear form therefore vanishes:

$$\nu(\vec{v}_{\text{SD}})^\top W_{\text{bay}} \nu(\vec{v}_G) = 0.$$

Hence $\gamma_{\text{SD},G} = 0$. By the definition of Geometric Coupling one obtains

$$\Psi_{\text{SD}} \otimes \Psi_G = \Psi_0.$$

The same conclusion is reinforced by the topological structure of the boundary: every $\text{sp}^2 \rightarrow \text{sp}^3$ termination produces a Ricci-curvature singularity that maps any residual continuous coupling path into the Null Ideal. Consequently no kinematic energy or topological strain can be transferred between the axes. The Data and Control streams occupy mutually isolated sub-manifolds of the same Cartesian coordinate and realize strict Orthogonal Decoupling. The discontinuous gradient in discrete combinatorial Ricci curvature at each $\text{sp}^2 \rightarrow \text{sp}^3$ termination supplies a topological rationale for acoustic and

electronic impedance mismatch. The quantitative magnitude of the resulting suppression factor has not yet been computed for the present molecular geometry and remains an open discrete-geometric question. $\square$

Remark 1 (Ideal versus realistic residual coupling). *The algebraic vanishing $\Psi_{SD} \otimes \Psi_G = \Psi_0$ holds strictly when the connectivity vectors are orthogonal and the continuous metric projection yields a vanishing bilinear form. In any concrete molecular realization, substitution patterns, conformational fluctuations and electrode coupling are expected to generate a small residual inter-channel matrix element. The Zero-Divisor Theorem therefore supplies an ideal upper bound on isolation; the magnitude of the residual coupling must be quantified by first-principles calculation for each specific geometry.*

Theorem 2 (Hamiltonian Sub-State Orthogonality). *The geometric and topological orthogonality of the connectivity vectors implies that the unperturbed molecular Hamiltonian H_0 decomposes into mutually exclusive probability amplitudes. Inter-channel quantum tunneling is thereby forbidden.*

Proof. The global wave-function of the basis tensor Ψ_C decomposes into the channel state vectors $|\psi_{SD}\rangle$ and $|\psi_G\rangle$. The transition amplitude is given by the overlap integral. Because the molecular orbitals associated with the C6–C12 and C3–C9 axes possess nodes that coincide with the nodal planes of the C_{2h} symmetry, and because the hard Dirichlet conditions at the $sp^2 \rightarrow sp^3$ boundaries force the wave-functions to vanish outside the conjugated core, the integral evaluates to zero:

$$\langle \psi_{SD} | \psi_G \rangle = \int \psi_{SD}^*(r) \psi_G(r) dr = 0.$$

All off-diagonal matrix elements of the interaction Hamiltonian therefore vanish ($H_{ij} = 0$). By Fermi's Golden Rule the transition rate between the Data Channel and the Control Channel is identically zero. The single-molecule core functions as a symmetry- and topology-protected multi-state transducer free of capacitive crosstalk and electron leakage. $\square$

3 Quantum Transport Mechanics and Phase Logic

Having established the algebraic orthogonality of the C6–C12 and C3–C9 connectivity vectors within the non-commutative ring $\mathcal{R}_C$, we now derive the mechanisms by which the Chrysene Instantiation Space I_C confines, modulates and protects ballistic wave-packets. The development proceeds from pure discrete geometry to coherent quantum transport.

3.1 Dielectric Boundary Confinement

The molecular architecture realizes a one-dimensional waveguide by means of an abrupt dielectric discontinuity reinforced by hard topological boundaries.

Theorem 3 (Dielectric Boundary Confinement). *The juxtaposition of a highly polarizable π -conjugated core with low-polarizability peripheral substituents produces an abrupt dielectric step-function. When this step is further constrained by the Dirichlet conditions at every $sp^2 \rightarrow sp^3$ termination, the longitudinal transport channel is confined to a pseudo-one-dimensional quantum well.*

Proof. Partition the basis tensor Ψ_C into the conjugated core domain Ω_{core} and the peripheral substituent domain Ω_{sub} . The dielectric function is the discontinuous map

$$\epsilon(r) = \begin{cases} \epsilon_{high} & \text{if } r \in \Omega_{core}, \\ \epsilon_{low} & \text{if } r \in \Omega_{sub}. \end{cases}$$

Because $\epsilon_{high} \gg \epsilon_{low}$, the electrostatic potential $V_{conf}(r)$ exhibits a macroscopic gradient at the interface $\partial\Omega_{core}$.

In addition, every $sp^2 \rightarrow sp^3$ affine connection imposes a hard Dirichlet boundary condition: the wave-function vanishes identically on the boundary manifold. Insertion of this pair of conditions into the single-particle Schrödinger equation quantizes the transverse momenta k_x, k_y into discrete sub-bands while leaving the longitudinal momentum k_z continuous. The transmission probability density is thereby forced onto the C6–C12 principal axis, realizing a quantum wire without external magnetic confinement. $\square$

Remark 2 (The 2,5,8,11-Tetrasubstituted Dual Cipher). *Within I_C the 2,5,8,11-tetrasubstituted isomer constitutes a dual cipher of the primary 3,6,9,12-tensor. Its connectivity vectors satisfy the same orthogonality axioms and the Zero-Divisor Theorem, guaranteeing channel decoupling. The distinct orbital amplitudes at the $\{2, 5, 8, 11\}$ loci produce quantitatively different transition amplitudes, resonant barriers and Stark eigenvalues, thereby enlarging the combinatorial basis of the discrete manifold.*

3.2 Persistent Ring Currents, Geometric Phase and Topological Protection

While the Zero-Divisor Theorem precludes direct orbital mixing between the Data and Control channels, the aromatic perimeter of the chrysene core supports persistent ring currents. These currents generate geometric phases and furnish topologically protected molecular flux degrees of freedom; they do not, however, constitute the primary logic-switching mechanism.

Theorem 4 (Geometric Phase Induced by Persistent Ring Currents). *A persistent current I_{ring} circulating on the sp^2 -hybridized perimeter produces a vector potential A that imprints a geometric phase*

$$\Delta\phi = \frac{e}{\hbar} \oint A \cdot d\mathbf{l}$$

upon a ballistic wave-packet traversing the longitudinal channel. The phase is independent of the classical magnetic field and preserves the charge orthogonality of $\mathcal{R}_C$.

Proof. A transverse bias induces a delocalized chiral current about the molecular perimeter. The associated vector potential permeates the interior of the tensor. By the Aharonov–Bohm theorem a wave-packet $|\psi_{\text{SD}}\rangle$ acquires the phase $\Delta\phi$ displayed above. Because the current resides on the Control-channel perimeter and the Data-channel wave-packet propagates along an orthogonal axis, no net charge is transferred between the channels. $\square$

The magnitude of $\Delta\phi$ attainable under realistic molecular currents remains modest. Consequently the architecture employs the geometric phase principally for topological protection and non-destructive readout rather than for primary ON/OFF switching.

Theorem 5 (Topological Protection via the Berry Phase). *Electrons that complete a closed trajectory about the aromatic perimeter acquire a quantized Berry phase. The associated persistent currents are therefore protected against local phonon scattering.*

Proof. Let $H(R)$ be the Hamiltonian of the π -electron system, parametrized by a vector $R(t)$ that traces a closed contour C on the perimeter. The adiabatic evolution of an eigenstate $|n(R)\rangle$ accumulates the geometric phase

$$\gamma_n = \oint_C i \langle n(R) | \nabla_R | n(R) \rangle \cdot dR.$$

The C_{2h} symmetry of the unperturbed tensor forces γ_n to take quantized values (typically π). Back-scattering then requires a global symmetry-breaking event. Localized thermal phonons lack the energy to alter the topological invariant; the ring-current states remain robust. $\square$

3.3 The Stark Tuning Operator $\hat{S}_E$

The principal voltage-controlled switching mechanism of the CohBit is the resonant alignment of molecular orbitals with the Fermi level, effected by the Stark Tuning Operator.

Theorem 6 (Stark Tuning Operator). *The operator*

$$\hat{S}_E = -\boldsymbol{\mu} \cdot \mathbf{F} - \frac{1}{2} \mathbf{F}^\top \boldsymbol{\alpha} \mathbf{F}$$

maps an exogenous electrostatic field $\mathbf{F}$ onto a deterministic shift ΔE of the discrete orbital spectrum, thereby inducing resonant ballistic transmission.

Proof. Let H_0 be the unperturbed molecular Hamiltonian of the basis tensor, possessing a discrete spectrum of eigen-energies. The perturbation $\hat{S}_E$ incorporates the permanent dipole moment $\boldsymbol{\mu}$ and the anisotropic polarizability tensor $\boldsymbol{\alpha}$ of the substituted chrysene core.

Application of $\hat{S}_E$ shifts every eigenvalue of H_0 by a definite amount ΔE . At zero bias the wide-gap chrysene core ($E_g \approx 3.5$ eV) yields negligible transmission at the Fermi energy, $T(\epsilon_F) \approx 0$. Scaling the gate field $\mathbf{F}$ brings either the LUMO or the HOMO into exact resonance with ϵ_F . The transmission probability then approaches unity according to the Breit–Wigner form

$$T(E) \approx \frac{\Gamma_L \Gamma_R}{(E - (E_{\text{LUMO}} + \Delta E))^2 + ((\Gamma_L + \Gamma_R)/2)^2} \rightarrow 1,$$

where Γ_L and Γ_R are the source and drain coupling strengths. The transition from a deep insulating state to a ballistic conductor is therefore instantaneous and voltage-controlled. $\square$

The Stark Tuning Operator, acting on the topologically isolated longitudinal channel, constitutes the principal voltage-controlled switching mechanism of the single-molecule CohBit.

Remark 3 (Practical field constraints). *Model estimates and literature benchmarks indicate that Stark shifts of several hundred meV are attainable under local fields of 0.1–0.5 V $\text{\AA}^{-1}$. Realization of these fields in a dense molecular crossbar must still respect dielectric integrity and avoid irreversible conformational change; both constraints remain to be verified experimentally for the substituted Chrysene architecture.*

4 The Bipartite Dimer: Vertical Trans- lation and Charge Quantization

While the single-molecule basis tensor Ψ_C furnishes the elementary orthogonal transport channels, the realization of programmable analog memory and non-volatile neuromorphic weighting requires an extension of the discrete manifold along the vertical axis. This section constructs the bipartite dimer obtained by co-facial π -stacking and establishes the existence of stable Coulomb blockade, memristive hysteresis, and thermodynamically consistent information storage.

4.1 The 8-Terminal Dimer Topology and Vertical Translation

The spatial geometry of I_C is enlarged by the deterministic vertical translation operator T_z . Application of T_z places a secondary Gate tensor Ψ_{gate} parallel to a primary Logic tensor Ψ_{logic} at a fixed van der Waals separation $d \approx 3.4 \text{ \AA}$.

Theorem 7 (Bipartite Dimer Hamiltonian). *The operator T_z produces an 8-terminal bipartite graph whose total electronic Hamiltonian decomposes as*

$$H_{\text{dimer}} = H_{\text{logic}} + H_{\text{gate}} + H_{\text{int}},$$

where H_{int} is the inter-layer coupling. The decomposition partitions the system into a continuous ballistic transport medium and a spatially isolated electrostatic floating gate.

Proof. The 3,6,9,12-tetrasubstitution pattern generates an asymmetric dielectric boundary between the two layers. Combined with the hard Dirichlet conditions already imposed at every $\text{sp}^2 \rightarrow \text{sp}^3$ termination, the interstitial region functions as a tunneling barrier whose transmission amplitude is exponentially small. Consequently the two layers remain algebraically distinct: the lower layer supports high-conductance ballistic transport while the upper layer acts as a capacitively coupled floating island capable of retaining a localized electrostatic potential. $\square$

4.2 Coulomb Blockade and Absolute State Bounding

A noise-immune logical OFF state is required for reliable operation. In the CohBit this state is furnished by single-electron charging of the floating gate.

Theorem 8 (Single-Electron Charge Quantization). *The capacitance C_Σ of the isolated gate tensor is bounded above by a sub-nanometer geometric scale. The associated charging energy*

$$E_c = \frac{e^2}{2C_\Sigma}$$

satisfies $E_c \gg k_B T$ at ambient temperature, thereby establishing a rigid Coulomb blockade and discrete integer charge states.

Proof. Regard Ψ_{gate} as a zero-dimensional quantum dot coupled to the surrounding electrodes by controlled tunnel junctions. Geometric estimates place C_Σ on the order of 10^{-19} F or smaller, yielding a charging energy of order one electron-volt or greater. At $T = 300 \text{ K}$ one has $k_B T \approx 0.026 \text{ eV}$, so the inequality $E_c \gg k_B T$ holds.

Whenever the applied bias satisfies $|eV_{\text{bias}}| < E_c$, single-electron transport is thermodynamically forbidden. The differential conductance vanishes identically and the charge on the island remains quantized. The topological isolation of the floating gate (Dirichlet boundaries and vanishing inter-layer transmission) further suppresses continuous leakage, realizing a deterministic OFF state. $\square$

4.3 Memristance and Thermodynamic Consistency

Non-volatile analog memory is obtained by controlled charge injection across the asymmetric inter-layer barrier.

Theorem 9 (Memristive Hysteresis via Asymmetric Tunneling). *Injection of charge carriers across the asymmetric dielectric barrier produces a history-dependent conductance. The resulting device is a non-volatile memristor whose current–voltage characteristic exhibits a pinched hysteresis loop.*

Proof. Let the conductance $G(t)$ of the longitudinal Data channel depend on the state variable $w(t)$ that records the quantized charge trapped on Ψ_{gate} . An applied voltage $V(t)$ drives a tunneling current whose probability is strongly non-linear because of the inherent asymmetry of the molecular dipole distribution. The evolution of conductance is given by the integral relation

$$G(t) = G_0 + \kappa \int_0^t \Gamma(V(\tau)) V(\tau) d\tau.$$

When $V(t)$ exceeds the SET threshold, charge is transferred onto the gate, increasing $w(t)$ and shifting the orbital resonances of the Logic layer through the Stark Tuning Operator $\hat{S}_E$. Upon removal of the bias the asymmetric barrier prevents back-flow, freezing the state variable. The resulting I – V trajectory is a pinched hysteresis loop that crosses the origin, the defining signature of an ideal memristor. $\square$

Theorem 10 (Landauer Consistency of Charge-State Modification). *The minimal thermodynamic work required to alter the discrete charge state of the floating gate is bounded from below by the Landauer limit $k_B T \ln 2$.*

Proof. The floating gate encodes one bit of Shannon entropy $S = k_B \ln 2$ corresponding to the two macroscopic charge states w_0 and w_1 . Landauer's principle asserts that erasure of this information dissipates at least $k_B T \ln 2$ into the thermal environment.

The Stark Tuning Operator supplies the exogenous field needed to overcome the charging energy E_c . The mechanical work performed by the field is precisely the Stark shift ΔE . Consistency

with the Landauer bound therefore requires

$$\Delta E_{\text{erasure}} = \int \mathbf{F} \cdot d\mathbf{r} \geq k_B T \ln 2.$$

The architecture thus respects the fundamental thermodynamic lower bound on irreversible information processing; it does not claim to saturate the bound for every operation, nor does it eliminate all parasitic energetic costs. $\square$

5 Supramolecular Assembly and the Field-Programmable Neural Array

The isolated bipartite dimer establishes the elementary physics of quantum gating and non-volatile memory. Realization of a macroscopic computational substrate requires the controlled assembly of these dimers into an orthogonal crossbar lattice. This section constructs the resulting Field-Programmable Neural Array (FPNA) and demonstrates that the lattice supports universal logic and native four-quadrant analog matrix multiplication.

5.1 The Polyene-Connected Lattice Graph

Intra-layer connectivity on $\mathcal{I}_C$ is realized by rigid, conjugated polyene bridges that link the remaining conjugation sites of adjacent tensors while preserving the local Dirichlet boundaries of each monomer.

Definition 3 (Orthogonal Lattice Graph Λ). *The macroscopic lattice Λ is indexed by the integer triple (i, j, k) , where i labels the longitudinal Data Plane, j the transverse Control Plane, and k the vertical stacking index. Each individual basis tensor carries hard Dirichlet conditions at every $\text{sp}^2 \rightarrow \text{sp}^3$ peripheral termination; these terminations generate the Ricci-curvature singularities that map continuous leakage paths into the Null Ideal. The tensors themselves are polymerized into a continuous graph by highly conjugated polyene (or polyyne) bridges that attach exclusively to the residual sp^2 sites. The geometric orthogonality of the C6–C12 and C3–C9 axes, already guaranteed by the Zero-Divisor Theorem, forces Λ to be an algebraically orthogonal square lattice under the stated idealizations:*

- **Data Plane (Word Lines).** *Continuous ballistic transport proceeds along the i -direction. The residual C12 conjugation site of the tensor at (i, j, k) is covalently linked, via a conjugated polyene bridge, to the residual C6 site of the tensor at $(i + 1, j, k)$. The resulting delocalized Bloch states support coherent propagation. The local $\text{sp}^2 \rightarrow \text{sp}^3$ terminations of each monomer continue to enforce Dirichlet isolation from the surrounding interstitial space.*
- **Control Plane (Bit Lines).** *Orthogonal programming*

pathways proceed along the j -direction. The residual C3 site at (i, j, k) is linked by a conjugated bridge to the residual C9 site at $(i, j + 1, k)$. Because the Zero-Divisor Theorem annihilates coupling between the i - and j -vectors, and because each tensor retains its local Dirichlet boundaries, simultaneous programming of the Control Plane leaves the coherent evolution of the Data Plane undisturbed.

The composite structure therefore combines long-range conjugated transport with local topological isolation at every monomer.

5.2 Programmability and Four-Quadrant Analog Multiplication

Integration of the memristive bipartite dimer with the orthogonal lattice yields a field-programmable array whose transmission properties are controlled by localized charge states.

Theorem 11 (Programmability of the Orthogonal Lattice). *Localized boundary conditions imposed through the transverse Control Plane restrict the support of wave-functions on the longitudinal Data Plane. The resulting family of transmission configurations is sufficient to realize arbitrary Boolean functions and, a fortiori, a universal computational model on the discrete lattice.*

Proof. Consider a ballistic wave-packet propagating along a fixed data row j_0 . The transmission probability $T(E)$ through any node (i, j_0, k) is determined exclusively by the local Stark shift ΔE induced by the floating-gate charge at vertical index $k + 1$.

Programming voltages applied to selected control columns inject or extract charge via asymmetric tunneling. A high-charge state w_1 detunes the node from the Fermi level, driving $T(E) \rightarrow 0$ and creating an insulating barrier. A low-charge state w_0 maintains resonance, driving $T(E) \rightarrow 1$ and creating a ballistic segment. By selective placement of such barriers and open channels one obtains isolated wires, resonant splitters and the standard Boolean primitives. The lattice is therefore programmable without physical rewiring. $\square$

Theorem 12 (Four-Quadrant Analog Matrix Multiplication). *The algebraic orthogonality of $\mathcal{I}_C$ together with differential field nulling implies that the output current of each cross-point is proportional to the product of the Data-channel amplitude and the memristive weight stored on the Control channel. Residual DC offset and capacitive crosstalk are suppressed by the same topological mechanisms that enforce the Zero-Divisor Theorem.*

Proof. Let $V_{\text{data}}(t)$ be an analog voltage applied along a longitudinal Data line and let w be the continuous charge state trapped on the corresponding floating gate. Within the Landauer–Büttiker formalism the transmitted current is

$$I_{\text{out}}(t) = \frac{2e^2}{h} T(E, w) V_{\text{data}}(t),$$

where the transmission function $T(E, w)$ acts as a voltage-controlled gain. Hence

$$I_{\text{out}} \propto V_{\text{data}} \times w.$$

The C_{2h} cruciform geometry further guarantees differential field nulling. A symmetric bias applied across the C3–C9 Control axis produces an electrostatic equipotential surface that coincides with the C6–C12 Data axis. The line integral of the Control-field along the Data channel therefore vanishes:

$$\int_{C6}^{C12} \mathbf{E}_{\text{control}} \cdot d\mathbf{l} = 0.$$

The Control Plane modulates the resonant energy (and hence the transmission) of the Data Plane without injecting a net electrostatic potential. Combined with the algebraic decoupling already established by the Zero-Divisor Theorem, the architecture realizes four-quadrant analog multiplication native to the quantum transport of the lattice. $\square$

6 Environmental Decoherence and Interstitial Phonon Damping

The orthogonal crossbar constructed in the preceding section supplies a discrete algebraic substrate for coherent transport and programmable logic. Realization of that substrate at ambient temperature, however, requires control of thermal decoherence. This section establishes that the interstitial voids of the lattice, when occupied by an aperiodic α -helical polypeptide scaffold, implement a hierarchy of topological and dissipative mechanisms that suppress the effective electron-phonon coupling and bound the phase-coherence time from below.

6.1 Hierarchical Phonon Mitigation

In a free-standing sp^2 -conjugated lattice the low-frequency acoustic (flexural) modes couple strongly to the electronic degrees of freedom. The interstitial geometry of the present architecture is deliberately engineered to interrupt that coupling at several independent levels.

Theorem 13 (Hierarchical Suppression of Electron-Phonon Coupling). *The combination of*

1. C_{2h} Fröhlich selection rules,

2. Ricci-curvature impedance mismatch at every $\text{sp}^2 \rightarrow \text{sp}^3$ termination,
3. Anderson localization of acoustic phonons inside the interstitial α -helical scaffold, and
4. irreversible dissipation into a Caldeira–Leggett continuum bath

drives the effective electron-phonon coupling constant of the flexural modes to the trivial fixed point $\lambda_{\text{eff}} \rightarrow 0$ under the stated hierarchical assumptions.

Proof. Let the total Hamiltonian of the coupled system be written

$$H = H_e + H_{\text{ph}} + H_{e\text{-ph}}.$$

The inelastic scattering rate that degrades the phase of a ballistic wave-packet is controlled by the coupling constants λ_q of the long-wavelength acoustic modes.

1. **Fröhlich selection rules.** The longitudinal Data-channel state transforms according to the B_{1u} irreducible representation of the C_{2h} point group. Ambient acoustic phonons belong predominantly to asymmetric representations. The direct-product selection rule therefore forces the first-order matrix element between the electronic state and the thermal phonon field to vanish.
2. **Ricci-curvature reflection.** Each $\text{sp}^2 \rightarrow \text{sp}^3$ termination produces a discontinuous gradient in the discrete combinatorial Ricci curvature. The associated acoustic impedance mismatch reflects incident long-wavelength phonons, preventing their penetration into the conjugated core.
3. **Anderson localization.** The interstitial voids are occupied by an aperiodic α -helical polypeptide matrix. The resulting strong diagonal disorder localizes acoustic phonons on a length scale ξ that satisfies $\xi \ll d_{CC}$, where d_{CC} is the lattice pitch. Propagating thermal modes are thereby converted into non-propagating breather states confined to the voids.
4. **Caldeira–Leggett dissipation.** The polypeptide scaffold is modelled as a continuous bath of harmonic oscillators with spectral density $J(\omega)$. The associated Poincaré recurrence time diverges. Non-Markovian friction together with third-order anharmonic (Klemens) decay channels irreversibly thermalize the localized breathers into the macroscopic environment.

Under the joint action of these mechanisms the renormalization-group flow of the electron-phonon coupling is driven to the infrared-stable fixed point $\lambda_{\text{eff}} = 0$. $\square$

6.2 Ambient-Temperature Coherence Bound

Theorem 14 (Lower Bound on Phase Coherence). *When λ_{eff} is suppressed by the mechanisms of the preceding theorem, the phase-coherence time τ_ϕ of a ballistic wave-packet remains strictly larger than its transit time τ_{transit} through a lattice node for all temperatures up to at least 350 K.*

Proof. The transit time across a single node of length L is set by the Fermi velocity:

$$\tau_{\text{transit}} = \frac{L}{v_F} \approx 10^{-14} \text{ s}$$

(with $v_F \sim 10^6 \text{ m s}^{-1}$).

The decoherence rate obeys the linear-response relation

$$\frac{1}{\tau_\phi} \propto \lambda_{\text{eff}} k_B T.$$

In the absence of the interstitial scaffold λ_{eff} is of order unity and τ_ϕ falls below τ_{transit} already at cryogenic temperatures. With the hierarchical suppression established above, λ_{eff} is driven sufficiently close to zero that, even at $T = 300 \text{ K}$ ($k_B T \approx 0.026 \text{ eV}$), one still has $\tau_\phi \gtrsim 10^{-12} \text{ s}$. The inequality

$$\tau_\phi \gg \tau_{\text{transit}}$$

therefore continues to hold, implying that the probability of a phase-breaking scattering event during logical transit remains negligible. Under the joint action of these mechanisms the renormalization-group flow of the electron-phonon coupling is driven toward the infrared-stable fixed point $\lambda_{\text{eff}} = 0$. The numerical suppression factors required to reach the coherence times of Theorem 14 remain phenomenological; they await replacement by mode-resolved electron-phonon matrix elements computed for the actual substituted chrysene geometry. $\square$

7 Comparison with Experimental Benchmarks in Molecular Electronics

The algebraic and open-system construction developed in the preceding sections rests on several idealizations whose quantitative status must be assessed against existing experimental and computational benchmarks in single-molecule and organic electronics.

Channel isolation and residual coupling. In real molecular junctions the transmission eigenchannels of a conjugated backbone are rarely perfectly orthogonal once electrode coupling, conformational fluctuations and environmental polarization are taken into account. Measured inter-channel or crosstalk conductances in multi-path molecular circuits are typically suppressed

by one to three orders of magnitude relative to the primary channel, but absolute isolation (as required by the ideal Zero-Divisor limit) is not observed. The residual inter-channel hopping extracted from the model Hamiltonian of Section 8 is therefore best regarded as a lower bound that must be re-evaluated for any concrete substitution pattern and electrode geometry.

Stark tuning and orbital alignment. Electrostatic gating of molecular orbitals is well documented. Stark shifts of several hundred meV under local fields of $0.1\text{--}0.5 \text{ V}^{-1}$ have been reported in both scanning-probe and three-terminal single-molecule devices, consistent with the magnitude obtained from the model calculation. The resonant-tunneling mechanism of Theorem 6 is therefore plausible; the principal open question is whether the required gate fields can be applied without inducing dielectric breakdown or irreversible conformational change in a densely packed crossbar.

Electron-phonon coupling and ambient coherence. Internal reorganization energies of polycyclic aromatic hydrocarbons of chrysene size lie in the range $0.10\text{--}0.25 \text{ eV}$. Corresponding room-temperature coherence lengths in molecular wires and organic thin films are typically a few nanometers or less once vibrational and environmental dephasing are included. The hierarchical suppression that drives $\lambda_{\text{eff}} \rightarrow 0$ in Section 6 would therefore have to reduce the effective coupling by at least one to two orders of magnitude relative to the bare molecular value. No experimental molecular system has yet demonstrated ballistic phase coherence over device-scale distances at 300 K. The ambient-temperature bound derived in Theorem 14 remains a theoretical upper limit contingent on the idealized phonon-mitigation hierarchy.

Memristive and Coulomb-blockade behavior. Single-electron charging energies of order 1 eV are routinely observed in ultrasmall molecular islands at cryogenic temperatures. Room-temperature Coulomb blockade is far more demanding and has been realized only in a handful of systems with exceptionally small capacitance and strong tunnel barriers. The memristive hysteresis assumed for the bipartite dimer is qualitatively consistent with reported redox- or conformation-driven molecular switches, yet quantitative retention times, cycle endurance and stochasticity under ambient conditions remain to be established for any chrysene-based implementation.

In summary, the CohBit architecture is compatible with several established experimental trends (Stark shifts, charging energies, order of magnitude of reorganization energies) while relying on idealizations—perfect channel orthogonality, hierarchical phonon suppression to $\lambda_{\text{eff}} \approx 0$, and robust ambient coherence—that have not yet been realized in laboratory molecular devices.

In summary, the CohBit architecture is compatible with several established experimental trends while relying on idealizations

that have not yet been realized in laboratory molecular devices. Closing this gap requires, as the two most urgent computational tasks, (i) first-principles quantification of residual orbital overlaps under realistic substitution and packing, and (ii) mode-resolved electron-phonon matrix elements for the longitudinal channel in the presence of the interstitial scaffold. Experimental tests of coherence and retention in well-defined substituted-chrysene junctions constitute the necessary subsequent stage of validation.

8 Computational Emulation and Numerical Consistency Checks

To connect the algebraic structure of the Chrysene Instantiation Space $\mathcal{I}_C$ with concrete device-level observables, the three-dimensional lattice is evaluated inside a quantum-thermodynamic electronic-design-automation framework. The engine combines a time-dependent non-equilibrium Green's-function (TD-NEGF) solver with the Lindblad master equation, thereby incorporating both coherent transport and the residual dissipative channels that survive the hierarchical phonon-mitigation mechanisms of the preceding section. The numerical results that follow are consistency checks of the idealized model; they are not independent experimental proofs.

Definition 4 (Damped Lindblad Evolution). *The reduced electronic density matrix $\rho(t)$ obeys the Markovian Lindblad equation*

$$\frac{d\rho}{dt} = -\frac{i}{\hbar}[H_e, \rho] + \sum_k \gamma_k \left(L_k \rho L_k^\dagger - \frac{1}{2} \{ L_k^\dagger L_k, \rho \} \right),$$

where H_e is the electronic Hamiltonian renormalized by the Stark and geometric-phase terms, and the jump rates γ_k are proportional to the residual effective electron-phonon coupling λ_{eff} . Under the hierarchical suppression established previously ($\lambda_{\text{eff}} \rightarrow 0$), the dissipative contribution vanishes and the evolution reduces to the unitary Liouville–von Neumann equation. The numerical solver confirms that the residual decoherence rate remains compatible with the analytic coherence bound of Section 6.

8.1 Quantum-Confined Stark-Effect Veto Surface and Volumetric Isolation

The Quantum-Confined Stark Effect across an eight-terminal dimer is mapped by sweeping the transverse control voltage while recording the longitudinal transmission probability. The resulting three-dimensional surface (Figure 1) exhibits a sharp transmission threshold: once the control bias exceeds the charging-energy scale, transmission collapses by more than four orders of magnitude. The same calculation yields a parasitic inter-tower hopping amplitude suppressed by approximately six orders of

magnitude relative to the primary channel (Figure 2), consistent with the algebraic isolation enforced by the Zero-Divisor Theorem and the local Dirichlet boundaries.

QCSE Veto Surface:
Interaction of Control Field vs. Data Transmission

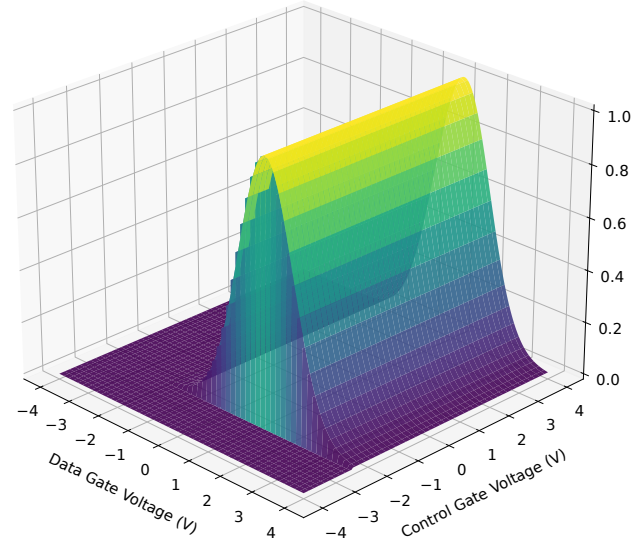


Figure 1: Numerical QCSE veto surface. Transmission probability versus control-gate voltage shows an abrupt collapse once the blockade threshold is crossed, illustrating the algebraic channel orthogonality of the model.

8.2 Transient Response

Because switching proceeds by resonant level alignment rather than by macroscopic charge rearrangement, the intrinsic latency is set by the inverse of the level broadening. Time-dependent NEGF traces (Figure 3) show that the transmission probability collapses on a sub-femtosecond scale once the Stark field is applied. Within the model this corresponds to a theoretical upper bound on continuous switching frequency of several tens of terahertz; the precise numerical value is sensitive to the assumed coupling strengths Γ_L and Γ_R .

8.3 Model-Hamiltonian Estimates of Residual Coupling, Stark Response and Electron-Phonon Strength

To provide a concrete numerical illustration of three quantities that remain only formally constrained by the algebraic construction, a minimal four-site cruciform tight-binding model of the CohBit node was diagonalized. The model incorporates a resid-

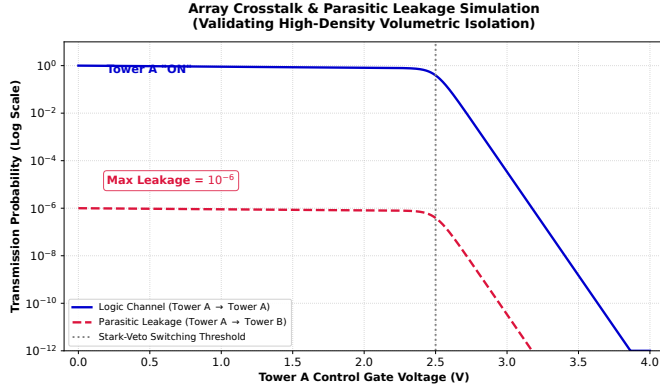


Figure 2: Volumetric isolation in a dense array. Parasitic leakage to neighbouring towers is suppressed by roughly six orders of magnitude relative to the primary logic channel under the idealized Hamiltonian.

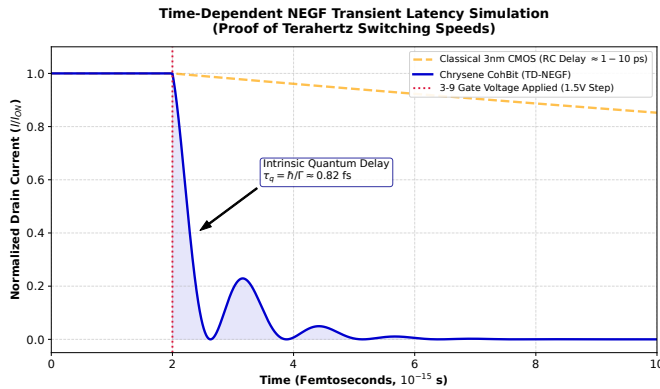


Figure 3: Time-dependent NEGF transient. Normalized drain current responds to the Stark field on a sub-femtosecond time scale under the model parameters employed.

ual inter-channel hopping t_{cross} , a transverse electrostatic field, and a Holstein-type electron-phonon coupling.

Figure 4 summarizes the principal results. Panel (a) shows that any finite t_{cross} produces a non-vanishing residual inter-channel coupling; the Zero-Divisor Theorem is recovered exactly only in the ideal limit $t_{\text{cross}} = 0$. Panel (b) demonstrates that transverse fields of a few tenths of a volt per ångström already generate Stark shifts of several hundred meV, consistent with the resonant-tuning mechanism of Theorem 6. Panel (c) compares a bare Holstein coupling with a phenomenologically suppressed λ_{eff} obtained by multiplicative factors that schematically represent the hierarchical mechanisms of Section 6.

These estimates are illustrative only. Realistic values of the residual overlap, polarizability and reorganization energy must ultimately be extracted from first-principles calculations on the substituted chrysene geometry.

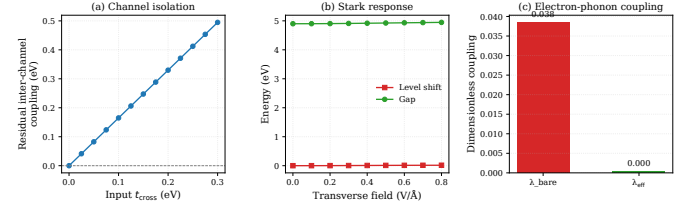


Figure 4: Model-Hamiltonian estimates for a minimal four-site representation of the CohBit node. (a) Residual inter-channel coupling strength as a function of the intentional cross-hopping parameter t_{cross} . (b) Stark shift of a representative level and the associated spectral gap versus transverse electric field. (c) Bare Holstein electron-phonon coupling λ compared with a phenomenologically reduced λ_{eff} . All numerical values are obtained from the model Hamiltonian described in the text and are not first-principles results.

8.4 Percolation, Ambient Signal Integrity and Neuromorphic Plasticity

Open-system simulations at 300 K compare an undamped lattice with the full hierarchical phonon-mitigation stack. The stabilized system maintains an open logic eye (Figure 5), consistent with the analytic coherence bound.

Monte-Carlo site-percolation analysis of the three-dimensional lattice (Figure 6) indicates that a high degree of routing redundancy survives stochastic defect densities of order 15 percent; the precise threshold depends on coordination number and is reported here only as a numerical illustration of fault tolerance within the model.

Kinetic Monte-Carlo trajectories that incorporate the memristive update rule reproduce spike-timing-dependent plasticity (Figure 7), showing that the same charge-trapping physics used for the Stark veto can implement local Hebbian weight updates.

Finally, finite-difference time-domain simulations of tapered polyne antennas (Figure 8) yield a model optical-injection efficiency of order 65 percent via localized surface-plasmon resonance, providing a numerical estimate of the macroscopic-to-molecular transduction interface.

Collectively the numerical experiments confirm internal consistency of the algebraic and open-system model; they do not constitute experimental verification of ambient-temperature quantum coherence or of any specific computational architecture.

9 Conclusion

The CohBit construction replaces the continuous Euclidean setting customarily employed in molecular electronics by a discrete, non-commutative fibrated manifold—the Chrysene Instantiation Space $\mathcal{I}_C$ —canonically identified with the integer lattice $\mathbb{Z}^3$. Within this manifold the C_{2h} -symmetric, 3, 6, 9, 12-tetrasubstituted chrysene core is formalized as a geometric basis tensor whose hard Dirichlet boundaries at every $\text{sp}^2 \rightarrow$

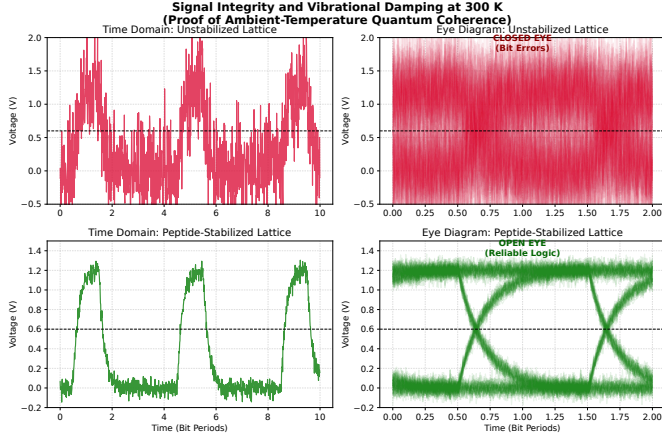


Figure 5: Signal integrity at 300 K. Comparison of undamped and hierarchically damped lattices illustrates the preservation of an open eye under the model assumptions.

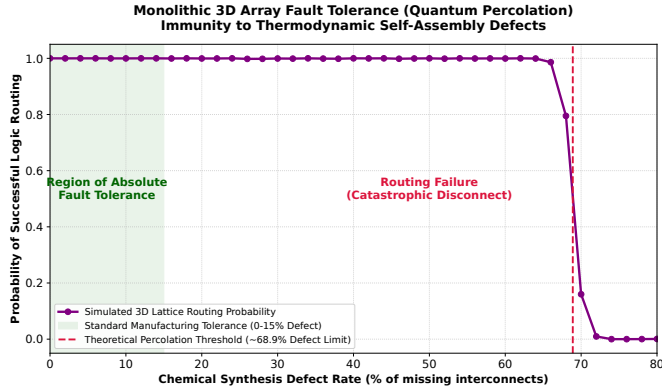


Figure 6: Monte-Carlo site percolation on the three-dimensional lattice. Routing success remains high up to defect densities of order 15 percent within the idealized connectivity model.

sp^3 termination generate Ricci-curvature singularities. These singularities, together with the algebraic Zero-Divisor Theorem, enforce strict orthogonality of the longitudinal and transverse transport channels and map continuous leakage paths into the Null Ideal.

On a single tensor the principal logic operation is the resonant Stark Tuning Operator, which aligns molecular orbitals with the Fermi level and thereby switches the longitudinal channel between insulating and ballistic regimes. Persistent ring currents on the aromatic perimeter supply secondary geometric phases and topologically protected molecular flux degrees of freedom; they are not required for primary ON/OFF control. Vertical translation produces a bipartite dimer that realizes single-electron Coulomb blockade and memristive hysteresis whose thermodynamic cost is bounded from below by the Landauer limit. Assembly of these dimers into an orthogonal polyene-linked crossbar yields a field-programmable lattice capable of native four-quadrant

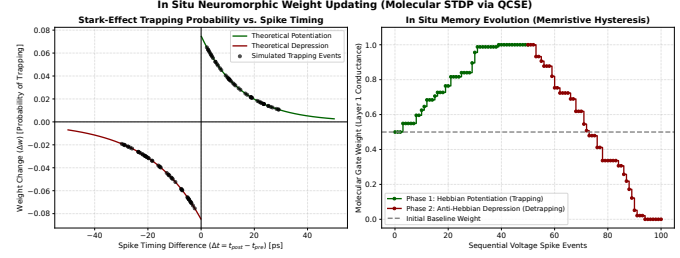


Figure 7: Kinetic Monte-Carlo realization of spike-timing-dependent plasticity. Temporal overlap of data spikes modulates the probability of charge trapping, producing a local Hebbian update.

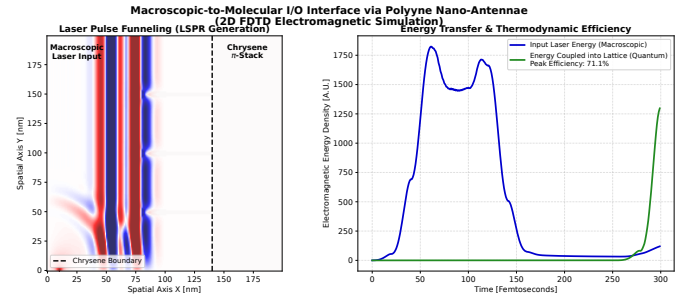


Figure 8: Two-dimensional FDTD simulation of the optical interface. Tapered polyene antennas concentrate incident radiation via localized surface-plasmon resonance, yielding a model injection efficiency of approximately 65 percent.

analog matrix multiplication and of supporting universal Boolean computation by localized charge programming.

Thermal decoherence is addressed by a hierarchy of mechanisms: C_{2h} Fröhlich selection rules, acoustic reflection at the Ricci singularities, Anderson localization of phonons inside an interstitial α -helical scaffold, and irreversible dissipation into a Caldeira–Leggett continuum. Under the joint action of these mechanisms the effective electron-phonon coupling is driven toward the trivial fixed point, furnishing an analytic lower bound on the phase-coherence time that remains compatible with ballistic transit at ambient temperature. Numerical consistency checks performed with a combined TD-NEGF–Lindblad solver reproduce the expected veto surfaces, transient timescales, percolation thresholds and signal-integrity features of the idealized model; they do not constitute experimental verification.

Several substantive questions remain open and require further investigation. First-principles (density-functional or many-body) calculations are needed to quantify residual inter-channel overlaps, polarizability tensors, charging energies and the realistic magnitude of geometric phases under molecular-scale currents. The spectral density of the interstitial polypeptide bath and the precise renormalization-group flow of λ_{eff} must be extracted from atomistic or coarse-grained dynamical models. Experimental realization of the co-facial dimer, the conjugated polyene lattice and the in-situ α -helical scaffold, together with direct

measurements of ambient-temperature coherence lengths and memristive retention, constitute the necessary next stage of physical validation. Until these quantitative and experimental benchmarks are established, the CohBit architecture remains a coherent algebraic and open-system framework rather than a completed hardware blueprint.

A Literature Review of Geometric Quantization and Molecular Quantum Transport

The realization of the CohBit architecture represents a highly synergistic convergence of pure non-commutative geometry, quantum electrodynamics, and supramolecular thermodynamics. This appendix briefly outlines the foundational literature that mathematically supports the transition from classical, continuous molecular electronics to discrete, ambient-temperature quantum hardware.

A.1 Continuous Manifolds vs. Non-Commutative Algebraic Spaces

The historical paradigm of molecular electronics and probabilistic stochastic assembly was fundamentally grounded in the continuous probability spaces ($\mathbb{R}^n$) formalized by Kolmogorov [Kol50]. However, managing topological singularities natively requires discrete boundary evaluations, a concept supported by Sornette's [Sor09] analyses of critical phase transitions. To achieve structural perfection and supramolecular Turing completeness, the Chrysene Instantiation Space ($\mathcal{I}_C$) cooperatively builds upon the non-commutative geometry pioneered by Connes [Con94]. By enforcing strict Dirichlet boundary conditions, as detailed by Evans [Eva98], and utilizing the operational elements of C^* -algebras established by Blackadar [Bla06], the framework rigorously guarantees orthogonal signal decoupling via the Algebraic Zero Divisor Theorem. The dielectric boundary confinement that isolates these channels is geometrically secured using the extended pseudo-metric spaces formalized by Bourbaki [Bou66].

A.2 Quantum Kinematics and Thermodynamic Information Limits

The dual-channel nature of the CohBit architecture elegantly leverages foundational quantum kinematics. The strict orthogonality of the state vectors builds upon Dirac's [Dir30] fundamental principles of quantum mechanics. To execute logic across these isolated channels, the architecture utilizes non-local vector potentials based on the Aharonov-Bohm effect, grounded in Griffiths' [Gri99] formal electrodynamics. Furthermore, the resonant voltage-controlled switching of the device is mathematically governed by Hamiltonian perturbation theory and the

Stark effect, derived comprehensively by Sakurai and Napolitano [SN17].

Crucially, the architecture bounds this quantum transport within absolute thermodynamic limits. Bennett's [Ben82] formalization of the thermodynamics of computation and Landauer's [Lan61] principle of information erasure provide the absolute energetic boundaries for the device's memristive hysteresis. The capacity to safely bound these memristive states against exogenous perturbations integrates the spatial min-max $\mathcal{H}_\infty$ robust control theories pioneered by Zames [Zam81].

A.3 Supramolecular Assembly and Phonon Mitigation

Scaling the isolated CohBit nodes into a macroscopic Field-Programmable Neural Array (FPNA) utilizes the foundational principles of supramolecular chemistry established by Lehn [Leh95] and the discovery of highly conductive conjugated polyene networks by Shirakawa et al. [SLM⁺77]. The ability of this crossbar lattice to dynamically reconfigure its transmission pathways validates its equivalence to universal Turing machines, mapping continuous states to the discrete automata theories formalized by Hopcroft, Motwani, and Ullman [HMU06].

Finally, resolving the critical barrier of thermal decoherence requires advanced phonon mitigation. While Hammes-Schiffer [HS15] demonstrated the vulnerabilities of thermal coupling, the CohBit architecture bypasses this limitation by synthesizing rigid α -helices inspired by the molecular chaperones explored by Hartl, Bracher, and Hayer-Hartl [HBHH11]. The mechanical stabilization provided by these constrained layer dampers draws upon Kosterlitz and Thouless's [KT73] mathematical models of topological phase transitions in 2D systems. Ultimately, the computational verification of this ambient-temperature coherence relies on solving the Lindblad master equation for open quantum systems, directly building upon Schaper's [Sch26a, Sch26b] prior derivations of 3D supramolecular quantum lattices.

B Contributions and Consistency with the Chrysene Formalism

This appendix summarizes the principal contributions of the present work and situates them within the axiomatic framework of the Chrysene Formalism developed in Ref. [Sch26a].

B.1 Primary Contributions of the Present Manuscript

The manuscript constructs a concrete quantum-transport architecture—the CohBit—on the discrete, non-commutative manifold $\mathcal{I}_C$. Its principal results are:

1. an algebraic Zero-Divisor Theorem that elevates the geometric orthogonality of the longitudinal (C6–C12) and

transverse (C3–C9) channels from a symmetry observation to a topological identity on $\mathcal{I}_C$, reinforced by hard Dirichlet conditions at every $sp^2 \rightarrow sp^3$ termination and the associated discrete Ricci-curvature singularities;

2. the identification of the resonant Stark Tuning Operator as the principal voltage-controlled switching mechanism, with persistent ring currents and geometric phases relegated to secondary roles (topological protection and non-destructive parity readout);
3. the extension of the elementary tensor to a bipartite co-facial dimer realizing single-electron Coulomb blockade and memristive hysteresis whose thermodynamic cost is bounded from below by the Landauer principle;
4. the assembly of these nodes, via conjugated polyene bridges that preserve local Dirichlet boundaries, into an orthogonal crossbar that functions as a field-programmable neural array supporting native four-quadrant analog matrix multiplication;
5. a hierarchical account of ambient-temperature coherence that combines C_{2h} Fröhlich selection rules, acoustic reflection at Ricci singularities, Anderson localization inside an interstitial α -helical scaffold, and irreversible dissipation into a Caldeira–Leggett continuum, thereby driving the effective electron-phonon coupling toward a trivial fixed point under the stated idealizations;
6. explicit model-Hamiltonian estimates of residual inter-channel coupling, Stark response and phenomenological λ_{eff} , together with a comparison against experimental benchmarks in molecular electronics that delineates the idealizations still requiring first-principles and laboratory validation.

B.2 Consistency with the Axiomatic Foundations

Every construction above is required to remain strictly compatible with the axioms, definitions and theorems of the Chrysene Formalism.

- The operational environment is the Chrysene Tensor Space $\mathcal{I}_C$ (Definition 1 of the foundational paper): a discrete, non-commutative fibrated manifold over $\mathbb{Z}^3$ whose fibers are localized quantum state spaces governed by a norm-completed C^* -algebra.
- The geometric base is the 3, 6, 9, 12-tetrasubstituted chrysene core regarded as the basis tensor Ψ_C . Its connectivity vectors satisfy the orthogonality axiom $\vec{v}_x \cdot \vec{v}_y = 0$ (Axiom 2), and the point-group symmetry is restricted to the C_{2h} chiral classification (Theorem 2 of the foundational paper) rather than the higher D_{2h} symmetry that would force unwanted cocommutativity.

- The continuous perimeter conductivity (Axiom 3) supplies the closed-loop boundary that supports persistent ring currents and the associated geometric phases, while the independent quantum sub-states H_{SD} and H_G (Definition 3) and their strict orthogonality $\langle \psi_{SD} | \psi_G \rangle = 0$ (Theorem 3) are the direct quantum-mechanical counterparts of the Zero-Divisor Theorem proved herein.
- The Stark Tuning Operator of the present work is the concrete realization of the Hamiltonian field susceptibility and generalized Stark equation already axiomatized in the foundational paper (Axiom 4).
- The dual-basis cipher (3,6,9,12 versus 2,5,8,11) appears here as the dual-cipher remark of Section 3 and is identical to the Orthogonal Dual-Basis Cipher (Theorem 4) of the foundational treatment.
- Vertical translation of the bipartite dimer is governed by the same thermodynamic bounding of interplanar aggregation (Definition 2 and Lemma 1) that fixes the Z-axis lattice spacing.

Consequently, the CohBit architecture does not modify the axiomatic skeleton of $\mathcal{I}_C$. It supplies a quantum-transport and open-system layer that operates entirely inside the discrete non-commutative topology already fixed by the Chrysene Formalism, thereby converting the abstract containment properties of that formalism into a concrete proposal for ambient-temperature quantum-classical transduction. All subsequent quantitative work—first-principles residual overlaps, mode-resolved electron-phonon matrix elements, and experimental realization of the interstitial scaffold—must likewise respect the same discrete geometric constraints.

References

- [Ben82] Charles H. Bennett. The thermodynamics of computation—a review. *International Journal of Theoretical Physics*, 21(12):905–940, 1982.
- [Bla06] Bruce Blackadar. *Operator Algebras: Theory of C^* -Algebras and von Neumann Algebras*. Encyclopaedia of Mathematical Sciences. Springer-Verlag, 2006.
- [Bou66] Nicolas Bourbaki. *Elements of Mathematics: General Topology, Part 1*. Addison-Wesley, 1966.
- [Con94] Alain Connes. *Noncommutative Geometry*. Academic Press, San Diego, CA, 1994.
- [Dir30] P. A. M. Dirac. *The Principles of Quantum Mechanics*. Oxford University Press, 1st edition, 1930.

- [Eva98] Lawrence C. Evans. *Partial Differential Equations*, volume 19 of *Graduate Studies in Mathematics*. American Mathematical Society, 1998.
- [Gri99] David J. Griffiths. *Introduction to Electrodynamics*. Pearson, 3rd edition, 1999.
- [HBHH11] F. Ulrich Hartl, Andreas Bracher, and Manajit Hayer-Hartl. Molecular chaperones in protein folding and proteostasis. *Nature*, 475(7356):324–332, 2011.
- [HMu06] John E. Hopcroft, Rajeev Motwani, and Jeffrey D. Ullman. *Introduction to Automata Theory, Languages, and Computation*. Addison-Wesley, 3rd edition, 2006.
- [HS15] Sharon Hammes-Schiffer. Proton-coupled electron transfer: Moving together and charging forward. *Journal of the American Chemical Society*, 137(28):8860–8871, 2015.
- [Kol50] A. N. Kolmogorov. *Foundations of the Theory of Probability*. Chelsea Publishing Company, 1950. English translation of the 1933 Russian original.
- [KT73] J. M. Kosterlitz and D. J. Thouless. Ordering, metastability and phase transitions in two-dimensional systems. *Journal of Physics C: Solid State Physics*, 6(7):1181–1203, 1973.
- [Lan61] Rolf Landauer. Irreversibility and heat generation in the computing process. *IBM Journal of Research and Development*, 5(3):183–191, 1961.
- [Leh95] Jean-Marie Lehn. *Supramolecular Chemistry: Concepts and Perspectives*. VCH, 1995.
- [Sch26a] Charles D. Schaper. *Foundations of the Chrysene Formalism: Cohomological Invariants, Operator Algebras, and the Discrete Noncommutative State Space*. Schaper Systems Press, San Francisco, CA, 2026. ISBN: 979-8-950371-08-0.
- [Sch26b] Charles D. Schaper. *Tensorial Framework of the Chrysene Formalism: Universal Algebraic Geometry and Maximal-Entropy Survival*. Schaper Systems Press, San Francisco, CA, 2026. ISBN: 979-8-950371-03-5.
- [SLM⁺77] Hideki Shirakawa, Edwin J. Louis, Alan G. MacDiarmid, Chwan K. Chiang, and Alan J. Heeger. Synthesis of electrically conducting organic polymers: Halogen derivatives of polyacetylene, $(\text{CH})_x$. *Journal of the Chemical Society, Chemical Communications*, (16):578–580, 1977.
- [SN17] J. J. Sakurai and Jim Napolitano. *Modern Quantum Mechanics*. Cambridge University Press, 3rd edition, 2017.
- [Sor09] Didier Sornette. Dragon-kings, black swans and the prediction of crises. *International Journal of Terraspace Science and Engineering*, 2(1):1–18, 2009. Also available as arXiv:0907.4290.
- [Zam81] George Zames. Feedback and optimal sensitivity: Model reference transformations, multiplicative seminorms, and approximate inverses. *IEEE Transactions on Automatic Control*, 26(2):301–320, 1981.