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Topological Fault Tolerance, Fiedler Routability, and Partially Bridged Percolation of the Interior Chrysene Lattice: Homological Bypasses, Directional Attachment Constraints, and the Exclusion of Degenerate Star Graphs

Charles D. Schaper, Ph.D.
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Declared review status

This is an AI-assisted simulated orthogonal review, not independently appointed human peer review. Separate mathematical and chemistry passes inform the revision. Concordance compares the manuscript, inherited report, computations and new companion files. Revision responses describe the prepared changes rather than unprovided author statements.

Scope of Review

The controlling input is Article 94's supplied `main.tex`. Its referee report and verification code are audited evidence. Finite combinatorics, general graph proofs, probability laws and proposed chemical implementation are assessed separately.

Combined recommendation

Retain the directional counting, conditional reliability and cubical bypass framework after substantive corrections. Distinguish the sharp 19-node plaquette neighborhood from the 27-node corner-closed box, correct the numerical counts and containment thresholds, and specify the probability and chemical-realization assumptions.

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1 Source record and historical review

The original report is preserved unaltered in `provenance/Article94_Prior_Referee_Source.tex`. Its October 2026 metadata and verdict "Accept with Minor Revisions (Four Topological & Percolation Enrichments)" are historical. Its arithmetic and verification claims are not adopted without the new checks.

main.tex SHA-256

`def6f3e464b64a1384b52d8f8271ca6f`

`afa8d7fee1b8ffb12488ccb350926305`

referee_report_a94.tex SHA-256

`6f28966b8c634d5a32cd16ea76a67ef9`

`ed79480f905b6910eb987c55825168ae`

verify_a94.py SHA-256

`587450a029b6e3535ced12ca784fb8ff`

`04995bef45eea2f53ea34f7b64d207b0`

1.1 Earlier recommendations retained as provenance

The historical report requested cubical Euler–Poincaré and boundary-rank identities, percolation-coupled size thresholds, pre-scission Fiedler values and a complete double-star edge sweep. These remain useful audit targets. For the supplied two-star graph with centers separated by three lattice steps and joined tips, direct Laplacian calculation gives $\lambda_2 \approx 0.09994745$, not the historical 0.1206. All single-edge deletions disconnect it. The current review supersedes the incorrect scalar sum and size thresholds, the inference that plaquette completeness alone forces a full box, and the assertion that equal ranks alone prove an integral homology quotient is zero. Contractibility provides the required homology argument for full cubical boxes.

2 Review architecture

> *M* — **Mathematical validity**
>
> Audit directional port counts, finite probability laws and endpoint cases, cubical chains, sharp local minima, graph deletion and distance bounds, and numerical containment calculations.

> *C* — **Concordance**
>
> Require agreement among theorem scope, abstracts, tables, numerical macros, scripts and formal certificates. Preserve superseded source claims without presenting them as current validation.

H — **Chemistry and domain admissibility**

Distinguish fixed-port geometry and unweighted adjacency from atom-balanced synthesis, molecular conformations, reaction kinetics, mechanics, transport and functional heredity.

3 Mathematical review and revision response

3.1 M1 Separate the sharp plaquette minimum from corner closure

Finding: major. Plaquette completeness forces a center, six axial neighbors and twelve two-coordinate diagonal neighbors, totaling 19 vertices. It does not force the eight three-coordinate corners. The induced set

$$Q_{19} = \{v \in \{-1, 0, 1\}^3 : \#\{i : v_i \neq 0\} \leq 2\}$$

realizes the predicate without being a 27-node box. The theorem's added corners are an independent hypothesis, while the original abstract and conclusion omit that distinction. The 54-node daughter-box claim likewise requires the strengthened predicate and specified cleavage model.

Revision response. Accept. State the sharp 19-node local minimum and introduce explicit corner closure to recover the 27-node box. Restrict the 54-node result to two disjoint corner-complete daughter neighborhoods in the prescribed construction. Retain direct exclusion of the tree stars, without claiming unrestricted box uniqueness.

3.2 M2 Correct the scalar partition sum and inherited test failure

Finding: major. The supplied verifier fails its scalar-sum assertion: it expects 254,121,840 but its loop computes 60,454,593. The fixed-locant and projected orbit sums 4,410,944 and 10,648,000 remain correct under their conventions.

Revision response. Accept. Replace the scalar macro and all occurrences by the executed value, and independently enumerate the 4,096 bridge masks. Add an independent count and negative control rather than retaining the false expected literal. Supersede the historical all-verified impression.

3.3 M3 Recompute containment ceilings from the printed constants

Finding: major. For $a_x = a_y = 7.90$, $h(n_z) = 1.38 + 0.34(n_z - 3)$, $d_{\mathrm{bl}} = 4.0$ and $c = 0.89923$, the displayed circumradius formula yields thresholds

$$(L_6, L_{10}, L_{12}, L_{18}) = (233, 239, 243, 259)\ mbp,$$

not $(222, 232, 239, 270)$. The corresponding wrapped radii are approximately 9.71358, 9.89401, 10.01111 and 10.45776 nm. The increase from six to twelve layers is 10 bp rather than 17 bp.

Revision response. Accept. Generate the revised values from the stated formula and certify the integer ceilings by exact comparisons where possible. Remove false agreement with earlier Article 80 numbers; the present calculation does not silently amend that earlier paper. Treat the input dimensions and radius law as model parameters.

3.4 M4 Type the homology and scission statements correctly

Finding: moderate. An oriented edge $e : u \to v$ and a bypass $\gamma : u \to v$ are not absolute cycles, so $[e]$ and $[\gamma]$ are undefined in absolute H_1. The cycle $e - \gamma$ bounds the oriented plaquette in the original complex. Removing an edge from a cubical complex also requires removing its incident higher cells if a subcomplex is claimed.

Revision response. Accept. Use the chain relation $e - \gamma = \pm\partial_2 p$ with consistent orientations, and define scission primarily as graph-edge deletion. Restrict the bypass equivalence to simple three-edge paths in the specified admissible cubic graph. State all path-substitution and retained-edge assumptions.

3.5 M5 Prove connectivity and the double-cut distance bound

Finding: moderate. Minimum degree three gives only an upper bound on edge connectivity. It does not prove equality. The single-plaquette argument also does not automatically prove the advertised double-cut stretch for general networks.

Revision response. Accept. For full boxes with side lengths at least two, use two internally edge-disjoint elementary-square detours around each edge. After at most two edge deletions, one detour around each removed edge avoids the other deletion. Path substitution gives stretch at most three and connectivity. A three-edge corner cut proves the matching upper bound. Restrict this conclusion to full boxes; retain exhaustive finite checks as corroboration, not the general proof.

3.6 M6 Specify the probability space and saturated endpoint

Finding: moderate. The product formula

$$P_{\mathrm{retain}}(p_b, h) = \left(1 - (1 - p_b^4)^{h-2}\right)^2$$

is valid for independent lateral-edge events with compatible preassigned sites, retained vertical contacts and the specified cleavage. Uniform sampling of family–edge pairs does not induce this Bernoulli law. The logarithmic minimum formula cannot be evaluated at $p_b = 1$.

Revision response. Accept. Define the Bernoulli law separately from the counting measure and state the scaffold prerequisites. Define $h_{\min}(1, \varepsilon) = 3$ directly. Restrict minima to the $3 \times 3 \times 2h$ family and distinguish geometric completeness, plaquette completeness, connectivity and biological inheritance.

3.7 M7 Separate projected family counts from oriented states

Finding: moderate. The projected orbit count identifies I and ιI whenever an orientation exists. With no incident x-edge this gives three families, although there are four orientation-resolved types $D, I, \iota I, T$. For oriented types the row sum is $64 + 16 + 16 + 4 = 100$ and the layer sum is 64,000,000. Extra decoration factors cannot be multiplied independently if they determine the same directional availability already counted.

Revision response. Accept. Name the projected and orientation-resolved ensembles separately. Retain the correct projected sum with its existential interpretation and report the oriented refinement.

Treat any constant-size decoration fibre as a separate explicit product-model assumption or remove the unsupported full-state factorization.

4 Concordance review and revision response

4.1 C1 Synchronize summaries and target dispositions

Finding. The original abstract, synthesis table and conclusion overstate box forcing and global minimality, and repeat erroneous numerical values.

Revision response. Accept. Update all summaries, hypothesis registers, table entries, captions and OJS text. Describe target conclusions at the scope actually proved, retaining open physical-realization and unrestricted-shape questions.

4.2 C2 Preserve historical provenance without adopting its verdict

Finding. The earlier report contains false arithmetic and computational assurance that the supplied program does not support.

Revision response. Accept. Preserve the original source unaltered as provenance. Explicitly distinguish the replacement calculations and new simulated review from the historical assessment. Generate numerical values from executed results.

4.3 C3 Match verification and formal coverage to claims

Finding. The source describes distance and boundary-rank checks more broadly than implemented. Finite sweeps do not formally prove the general analytic results or imported chemistry.

Revision response. Accept. Add explicit tests and mutation controls for the identified defects, audit the executed code and embedded listings, and state the exact finite scope of the Lean certificates. Separate general manuscript proofs, exact computations, floating-point spectra and chemical hypotheses.

5 Chemistry review and revision response

5.1 H1 Distinguish prescribed ports from flexible molecular geometry

Finding: major. Locants alone do not establish that a flexible arm can never reach another spatial direction. The directional theorem is valid within a common fixed frame and prescribed exact-closure port model.

Revision response. Accept. Qualify all directional claims by the fixed-port convention. Leave alternative orientations, linker reach and conformations outside this theorem and identify structural characterization as an empirical target.

5.2 H2 Conserve phosphorus in the proposed bridge chemistry

Finding: major. The original equation combines two phosphate-bearing arms into a drawn one-phosphorus diester plus water. It does not conserve phosphorus. A two-phosphate anhydride would be a different product, not an interchangeable correction.

Revision response. Accept. Remove the unbalanced equation. Describe a proposed one-phosphorus bridge and require a balanced synthesis route, activation and leaving-group chemistry separately. Do not silently substitute a phosphoanhydride.

5.3 H3 Do not infer rapid hydrolysis or spontaneous repair

Finding: major. Phosphodiester cleavage rates depend strongly on structure and conditions. A 12-hour hydrolysis premise is not established for the proposed bridge, and proximity does not provide phosphate activation or the free energy of re-ligation. Simple phosphate diesters can be exceptionally resistant to uncatalyzed attack at phosphorus [1].

Revision response. Accept. Present chemical repair as a conditional, experimentally testable activated-religation mechanism. Separate installation probability at a defined observation time from cleavage and repair rate laws. Reagent-dependent prebiotic phosphorylation studies on other substrates [2] are precedents for specificity, not validation of this chrysene reaction.

5.4 H4 Separate connectedness from mechanical and functional survival

Finding: major. Positive unweighted Fiedler connectivity proves connectedness. It does not establish rigidity, strength, molecular registration, electronic transport or useful chemical routing. Covalent links and noncovalent stacking contacts cannot be assigned identical physical lifetimes merely because both are graph edges.

Revision response. Accept. Replace mechanical-integrity and permanent-disconnection language by graph connectedness under retained-edge assumptions. Identify weighted kinetic or elastic models and functional assays as additional work.

5.5 H5 Separate combinatorial and chemical ensembles

Finding: moderate to major. A family–bridge counting sum is not automatically a thermodynamic partition function. Steric and chemical coupling can correlate edge formation; bulk conversion does not establish independent equal edge probabilities. The 95% event probability is model reliability, not a statistical confidence interval or proof of heredity.

Revision response. Accept. Describe the count and Bernoulli probability law separately, state the fixed-scaffold assumptions and require tests of edge-occupancy correlations. Reserve biological inheritance for additional persistence, cleavage, retention and functional evidence.

5.6 H6 Qualify the genome and packing interpretation

Finding: moderate. The radius law, axial step, lateral span and membrane thickness are imported parameters, not universal dimensions. An integer length threshold from this model does not establish a minimum functional genome or a viable protocell.

Revision response. Accept. Retain the conditional containment calculation while qualifying abstracts, captions and conclusions. Identify packing and membrane measurements needed to calibrate the assumed size law.

5.7 H7 Specify an empirical closure plan

Finding: moderate. Generic mass spectrometry and two-dimensional phosphorus NMR cannot by themselves recover specific edge occupancy or network independence.

Revision response. Accept. Propose authenticated bridge/speciation standards, appropriate LC/HRMS and multinuclear or solid-state NMR, geometry and morphology measurements, time-resolved installation/cleavage/dissociation/activated-religation assays, occupancy-correlation tests, and separate mechanical or transport measurements. These remain experimental targets.

6 Integrated disposition and verification evidence

All numbered recommendations are accepted as scope-preserving corrections. No chemical experiment is added or implied, and no model result is discarded merely because molecular realization remains to be tested. The distinction between the 19-node predicate and strengthened box closure is a substantive correction to the original claim, not a change hidden in presentation.

6.1 Execution and formal coverage

The revised Python suite executes 29,784 explicit checks in each of normal and optimized modes, with identical outputs: 29,776 exact predicates and eight numerical checks. Ten negative controls are included. Exact checks cover configuration counts, selected cubical boundary ranks over $\mathbb{F}_2$, graph cuts and bypasses, the 19-node neighborhood, probability thresholds and corrected containment ceilings. Numerical Laplacian values corroborate connectivity; they are not substituted for the graph proofs.

Lean 4.24.0 freshly compiled and audited 42 named finite theorems, all reported axiom-free. The companion gives the individual statements. Its coverage includes selected row/layer counts, cell and Euler counts, finite reliability inequalities, and boundary identities. It does not formalize every exhaustive Python sweep, the general metric theorem, integral homology of all boxes, imported corpus results, molecular realization or empirical kinetics. The full cubical integral-homology assertion rests on the manuscript's contractibility argument, not a rank computation over a finite field.

The package includes executable sources, matching LaTeX listings, input/source hashes, reproduction scripts and execution records. These distinguish exact finite evidence from general mathematical proof and proposed chemistry.

6.2 Closure and remaining scope

The focused chemistry pass confirms that H1–H7 are implemented and accurately represented here. The mathematical pass supports the substantive repairs and requested three final consistency edits: align the oriented bypass convention, state explicitly that the containment formula substitutes

$h = h_{\min}$, and correct the displayed approximate count ratio. The revision incorporates these clarifications before release.

The final disposition is preparation for author review, not a claim of journal acceptance. The finite graph and probability framework is retained with corrected arithmetic and explicit assumptions. The external corpus theorem-number attributions and imported molecular realization are not certified by these finite supplements. Experimental bridge chemistry, correlated failure, mechanics and functional inheritance remain separate validation targets.

References

[1] G. K. Schroeder, C. Lad, P. Wyman, N. H. Williams and R. Wolfenden. The time required for water attack at the phosphorus atom of simple phosphodiesters and of DNA. *PNAS* **103**(11), 4052–4055 (2006). https://doi.org/10.1073/pnas.0510879103.

[2] C. Gibard et al. Phosphorylation, oligomerization and self-assembly in water under potential prebiotic conditions. *Nature Chemistry* **10**, 212–217 (2018). https://doi.org/10.1038/nchem.2878.