MATHAUDIT / DETAILED REPORT

Correctness, proof completeness, novelty, and source audit

Interpreting the (signed) chromatic polynomial coefficients via hyperplane arrangements

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Prompt	Standardized prompt
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Scope	Statements, proofs, novelty, and proof-critical source use

Important limitation. AI-generated analysis. This report is not a correctness certificate or a substitute for expert scrutiny. A Correct status may coexist with yellow typos or minor formal corrections that do not affect substantive soundness. It means that this audit found no unresolved substantive error under the stated criteria; it is not formal verification and should remain open to expert challenge and correction.

SUMMARY

01	Statements	Contains wrong statements
02	Proofs	Contains incorrect or incomplete proofs
03	Novelty	No non-novelty findings
04	Sources	Contains incorrect or incomplete source use

01 / STATEMENTS

Statements

Contains wrong statements

The generic projection formula and the braid, graphical, and natural-unit-interval interpretations are correct. The type-B extension is false as stated: Definition 6.7 can fail to produce a partition, and an exact rank-two example contradicts Theorem 6.17, Corollary 6.18, and Theorem 6.8. Separately, Remark 6.4's claimed bijection with simple signed graphs is false when both opposite-sign edge orbits occur. Allowing signed multigraphs repairs that remark but not the type-B projection theorem.

Theorem 2.5: The generic projection formula is stated correctly

PDF pages 4–5 · Theorem 2.5 · arXiv:2506.00941v2

Correct

For a real arrangement and a generic point, the number of regions whose metric projection lies in a k-dimensional face equals the absolute k-th characteristic coefficient. Kabluchko's exact Theorem 1.2 proves this dimension-indexed form directly; Lofano–Paolini Corollary 5.14 independently gives the codimension-indexed Betti form. The paper's sign convention is consistent with both.

Verifiable source: Exact arXiv version 2

Theorems 3.3 and 4.4: The braid and graphical source-component interpretations are correct

PDF pages 6–14 · statements and complete proofs of Theorems 3.3 and 4.4 · arXiv:2506.00941v2

Correct after harmless local notation repair

In the braid arrangement, the block containing each right-to-left minimum is exactly the next block exposed by the projection. In a graphical arrangement, the analogous blocks are the source components of the region's acyclic orientation. The strong coordinate separation makes the canonical face uniquely closest. In the type-A lower-bound calculation, one occurrence of p_i where the comparison uses the competing projection q_i is a uniquely determined symbol slip; the preceding equal-block identity makes the repaired line valid.

Theorem 5.2 and Corollary 5.3: The natural-unit-interval specialization and factorization are correct

PDF pages 15–17 · Theorem 5.2, Corollary 5.3, and proofs · arXiv:2506.00941v2

Correct

For a natural unit interval graph, the permitted descents force each source component to begin at a right-to-left minimum, and every such minimum begins one component. Counting the eligible choices gives the displayed product for the characteristic polynomial. The endpoint and isolated-vertex cases agree with the graph and arrangement dimensions.

Remark 6.4: Simple symmetric graphs do not biject with simple signed graphs

PDF pages 18–19 · Remark 6.4 and its signed-graph construction · arXiv:2506.00941v2

Incorrect · verified scope repair

On signed vertices $\{\pm 1, \pm 2\}$, a simple symmetric graph may contain both orbits $\{\{1,2\},\{-1,-2\}\}$ and $\{\{1,-2\},\{-1,2\}\}$. The proposed quotient then needs both a positive and a negative edge between vertices 1 and 2, which a simple graph with one sign function on its edge set cannot encode. Zaslavsky's cited framework allows parallel edges of opposite signs. Thus the remark is repaired by allowing signed multigraphs, or by forbidding simultaneous opposite-sign orbits.

Definition 6.7: The signed-source construction need not produce a partition

PDF page 19 · Definition 6.7 · arXiv:2506.00941v2

Incorrect definition · explicit counterexample

In the branch $-m \in R_m$, the definition updates the zero block B but never defines S_k, although the next recursive stage uses it. Even with the obvious repair $S_k = \varnothing$, take the symmetric graph with edges $\{1,-1\}$, $\{1,-2\}$, and $\{-1,2\}$ and the region oriented $1 \to -1$, $1 \to -2$, $2 \to -1$. The first stage gives $B = \{\pm 1\}$; the second gives $S_2 = \{2,-1\}$. Thus $S_2 \cap B = \{-1\}$, so the displayed antipalindromic sequence is not a partition.

Theorem 6.17, Corollary 6.18, and Theorem 6.8: The type-B projection and coefficient theorems are false as stated

PDF pages 20–23 and 25–28 · Theorems 6.8 and 6.17, Corollary 6.18, Remark 6.20, and proof · arXiv:2506.00941v2

Incorrect · explicit rank-two counterexample

Use the symmetric graph with edges $\{1,-1\}$, $\{1,-2\}$, and $\{-1,2\}$, whose arrangement is $x_1 = 0$ and $x_1 + x_2 = 0$. For the region $R = \{x_1 \le 0,\ x_1 + x_2 \le 0\}$ and $v = (58, 1)$, the separation hypothesis holds because $58 > (14 \cdot 2^2 + 1) \cdot 1 = 57$. The KKT identity $(58,1) = 57(1,0) + (1,1)$ shows that $\mathrm{proj}_R(v) = (0,0)$, a zero-dimensional face. Definition 6.7 instead gives one signed source component, so Theorem 6.17 predicts dimension one. Across all four regions, the signed-source counts are $(1,1,1,2)$ while the projection dimensions are $(0,1,1,2)$; hence the distribution also contradicts Corollary 6.18 and Theorem 6.8, since $\chi_{\mathcal{A}}(q) = (q-1)^2$.

02 / PROOFS

Proofs

Contains incorrect or incomplete proofs

Sections 2–5 have complete proofs after one harmless symbol repair. The proof of the type-B main theorem is not valid as written, and the exact rank-two counterexample shows that the theorem cannot be repaired only by filling its gaps. Definition 6.7 can fail before Lemma 6.24 applies; separately, the lemma omits its universal signed-containment argument, the split-block contradiction uses the wrong face and reachability closure, and the two distance cases contain several incorrect estimates.

Lemma 6.24: The universal signed prefix containment is asserted but not proved

PDF page 25 · Lemma 6.24 and its final proof sentence · arXiv:2506.00941v2

Incomplete · unresolved

The lemma first says that the canonical signed-source partition labels a face, but Definition 6.7 does not even produce a partition in the rank-two counterexample recorded above. The natural disjointness repair $S_2 := R_2 \setminus B = \{2\}$ gives the sequence $(\{2\}, \{\pm 1\}, \{-2\})$, whose face has $x_1 = 0$ and $x_2 > 0$ and is not a face of the region $x_1 \le 0$, $x_1 + x_2 \le 0$. Its stronger universal-prefix clause is also asserted only by analogy with type A. Reiner identifies type-B flats but supplies neither a zero-block saturation rule nor this ordered-face containment, so both clauses remain defective.

Split-block claim in Theorem 6.17: The higher-dimensional face and reachability argument do not yield the stated contradiction

PDF pages 25–26 · first claim in the proof of Theorem 6.17 · arXiv:2506.00941v2

Incorrect and incomplete as written

The proof starts from the hypothesized nearest face F' and splits one of its blocks, so the refined face must contain F' in its closure for the strict distance contradiction. The text instead says twice that the higher-dimensional face contains the canonical face F. More seriously, D'_t is defined as the vertices reachable from $b_{i'}$, while moving that block later requires the opposite closure condition: with the paper's orientation, a path $\beta \to \alpha$ gives $x_\alpha \ge x_\beta$, contrary to the ordering inference printed in the subclaim. A backward-closed or component-based refinement might repair the strategy, but the manuscript does not prove that the resulting split labels a face of the region.

Error bounds in Theorem 6.17: The tail denominator changes from $14n^2 + 1$ to $6n^2 + 1$

PDF page 27 · displayed bound for ε_3 in the proof of Theorem 6.17 · arXiv:2506.00941v2

Incorrect typo · uniquely repairable

The separation hypothesis and the preceding pointwise estimate use $14n^2 + 1$, but the next display bounds ε_3 with $(6n^2 + 1)^2$. The following combined estimate returns to $(14n^2 + 1)^2$. Replacing 6 by 14 is forced and only strengthens the stated bound.

Case 1 of Theorem 6.17: The strict coefficient gap is valid once the decomposition is valid

PDF page 27 · case $B_0 = D_0$ in the proof of Theorem 6.17 · arXiv:2506.00941v2

Local lower bound verified; upstream dependence unresolved

For integers $b < d \le n$, one has $1/b - 1/d \ge 1/(n-1) - 1/n = 1/(n(n-1)) > 1/n^2$. Thus the final displayed strict inequality in Case 1 is sound after the denominator repair. It does not close the theorem because obtaining the first differing blocks still uses Lemma 6.24 and the failed split-block claim.

Case 2 of Theorem 6.17: Zero-block sums and the special-coordinate estimate are not a valid distance comparison

PDF pages 27–28 · case $B_0 \neq D_0$ in the proof of Theorem 6.17 · arXiv:2506.00941v2

Incorrect and incomplete as written · unresolved

The Euclidean norm sums once over coordinates $1, \dots, n$, but a zero block contains both i and $-i$; sums over all $i \in B_0$ therefore double count unless restricted to one representative, such as $B_0 \cap [n]$. The element β is chosen as the least signed element rather than least in absolute value, so the later minimality claims do not follow. If the asserted conclusion $\beta = -\alpha$ is used, the displayed square has the wrong sign: it should involve $(v_{|\beta|} + q_\beta)^2$, not a difference. Finally, the coordinate β is already part of the later-block error estimate for the competing projection, yet its lower bound is added again afterward. The numerical fact $1/b - 1/d > 1/n^2$ remains correct, but the preceding upper and lower bounds do not justify applying it. A new disjoint coordinate decomposition is needed.

Sections 3–5: The type-A and natural-unit-interval proofs close

PDF pages 6–17 · proofs of Theorems 3.3, 4.4, and 5.2 · arXiv:2506.00941v2

Correct after one symbol repair

The ordered-partition projection formula, prefix containment, and first-differing-block estimate are complete in type A. In one lower-bound line p_i must be q_i, but all earlier blocks are equal, so the unique repair preserves the equality used next. The natural-unit-interval argument then identifies the source components with the permitted right-to-left minima and requires no type-B claim.

03 / NOVELTY

Novelty

No non-novelty findings

No non-novelty findings.

04 / SOURCES

Sources

Contains incorrect or incomplete source use

The exact projection, graphical-arrangement, type-B flat, signed-orientation, and signed-characteristic source claims were traced, and their marked theorems are correct. The source-use verdict is adverse because the signed-graph sources allow parallel opposite-sign edges while the focal text narrows them to a simple-graph bijection. Reiner is correctly cited only for unordered type-B flats; the later ordered-face claims are presented internally, not attributed to Reiner. The inaccessible Lofano–Paolini publisher PDF is explicitly handled by an arXiv-version fallback and accepted-manuscript comparison.

Projection formula: Kabluchko is exact; Lofano–Paolini is an explicit fallback

PDF pages 4–5 · Theorem 2.5 and citations [5]–[6] · arXiv:2506.00941v2; Kabluchko journal page 1479; Lofano–Paolini arXiv:1809.02476v2 pages 20–21

Correctly invoked with one access limitation

Kabluchko Theorem 1.2 matches the focal formula exactly and was checked in an open version of record. Lofano–Paolini Corollary 5.14 gives the equivalent codimension and Betti-number count; exact arXiv version 2 and the institutional accepted manuscript agree, but the publisher PDF was not freely retrievable. Either source independently suffices, so that access limitation does not weaken the focal theorem.

Graphical inputs: Stanley's two marked results have exact applicability

PDF pages 9–10 and 15–17 · graphical and natural-unit-interval sections · arXiv:2506.00941v2; Stanley printed pages 414–418 · Theorem 2.7 and Proposition 2.5

Correctly invoked

Stanley's region and acyclic-orientation bijection applies to the same simple graphical arrangement, and his polynomial identity identifies its characteristic polynomial with the graph chromatic polynomial. The focal source-component and right-to-left-minimum refinements are then proved internally rather than attributed to Stanley.

Type-B flats: Reiner correctly supports the flat identification; it does not supply the later internal claims

PDF pages 21–25 · discussion before Definition 6.16 and Lemma 6.24 · arXiv:2506.00941v2; Reiner journal pages 197–199

Correctly invoked; limited to flats

Reiner's exact article identifies type-B intersection flats with sign-stable partitions and one possible zero block, exactly as cited. The focal paper then introduces the antipalindromic ordering and universal prefix-containment claim internally; it does not attribute those later claims to Reiner. Their defects are therefore internal proof defects rather than misuse of this source.

Signed-graph arrangement inputs: The exact sources use a wider multigraph convention

PDF pages 18–23 · Remark 6.4, Theorems 6.8 and 6.12, and Lemma 6.14 · arXiv:2506.00941v2; Zaslavsky 1991 Theorem 4.4 and Zaslavsky 2012 Lemma 4.3

Incorrectly narrowed in the focal translation

Zaslavsky's orientation theorem and signed chromatic and characteristic identity are correct, but the source framework permits multiple edges, including positive and negative links with the same endpoints. The focal construction defines a simple signed graph with a single sign function, so it cannot represent every simple symmetric graph. Allowing signed multigraphs restores applicability of the source theorems; it does not resolve the separate projection proof gaps.

Recursive source closure: Every marked non-book source was checked through its proof-critical chain

PDF pages 4–5, 9–10, and 18–25 · all externally sourced steps in the audited claims · arXiv:2506.00941v2

Complete apart from the explicit limitations above

Kabluchko was traced through KVZ and Stanley; Lofano–Paolini through Orlik–Solomon, Orlik–Terao, and Zaslavsky's region monograph; the signed orientation and characteristic branches through Zaslavsky's 1982 vector theorem. Recursion stops at published books or chapters. Contextual citations, independently reproved results, and comparison papers are recorded separately rather than turned into proof edges.

METHOD

Scope and decision rules

This audit addressed only the correctness of central statements, the correctness and completeness of proofs, evidence-backed non-novelty, and the correctness and completeness of proof-critical source use. It did not evaluate importance, exposition, style, suitability for publication, or author reputation.

An adverse finding is included only where the report can give a direct calculation, counterexample, formal contradiction, or a verifiable source establishing the precise claim. An inability to verify is kept distinct from a demonstrated defect. Technical compression is not treated as incompleteness when the omitted reasoning is recoverable and correct.

Before any finding was recorded, the argument was closed under immediate, mechanically checkable consequences of facts already established. An observation was suppressed when the printed conclusion followed by elementary logic, direct substitution, weakening, inclusion, or verified monotonicity and no substantive proof obligation or textual correction remained.

Typographical errors and minor formal corrections remain fully visible in yellow with their locations and repairs. When such a defect is unambiguous, local, and harmless to the paper's substantive conclusions, it does not lower the overall statements or proofs status from Correct.

The novelty panel reports only central results for which a verifiable primary source predating the earliest public version that contains the result proves the same statement up to notation, or from which the statement follows directly and immediately. It contains no positive novelty certifications and no entries based merely on an unsuccessful literature search.

All mathematical expressions in this report are compiled by LaTeX. The web presentation independently validates and renders the corresponding expressions with KaTeX.

Sources checked

1. Source paper: arXiv:2506.00941v2

2. Exact arXiv version 2

arXiv acknowledgement

Thank you to arXiv for use of its open access interoperability. This service was not reviewed or approved by, nor does it necessarily express or reflect the policies or opinions of, arXiv.

APPENDIX

Standardized prompt and in-depth source supplement

You are a mathematical auditor. Evaluate only the correctness of the paper's central statements, the correctness and completeness of its proofs, and evidence-backed non-novelty. Do not make editorial comments or evaluate importance, exposition, style, or suitability for publication. Keep the report neutral, precise, and professional.

PART 1 — CORRECTNESS OF THE MAIN STATEMENTS

Identify the paper's central statements and assess each one separately using exactly one of these outcomes:

- Correct: the statement has a correct, verifiable proof; or, despite a defect in the printed proof, you can give a fully verified repair or independent proof.

- Incorrect: you can give strong formal evidence that the statement as written is false, preferably a counterexample or a complete contradiction.

- Not able to verify: the supplied proof does not establish the statement, and you can neither supply a fully verified proof nor disprove it.

For every adverse or unverified outcome, restate the exact claim and hypotheses, identify its location in the reviewed version, and give the decisive reasoning. Do not infer that a theorem is false merely because its printed proof is defective.

Assign the overall statements status by the following priority:

1. Contains wrong statements, if at least one central statement is Incorrect.

2. Contains unsupported statements, if no central statement is Incorrect but at least one is Not able to verify.

3. Correct, if every central statement is Correct, apart from any typographical or minor formal findings allowed by Part 4.

PART 2 — CORRECTNESS AND COMPLETENESS OF THE PROOFS

Audit the proofs of the central statements and every material internal or cited input on which they depend. For each proof or proof segment, use the narrowest supported outcome:

- Correct and complete: every substantive step is verifiable and no case or crucial nontrivial step is missing.

- Incorrect as written: a displayed calculation, inference, lemma, or cited application is formally false or inapplicable.

- Incomplete as written: a necessary substantive step or case is missing, even though no explicit contradiction has been proved.

- Not able to verify: the available paper and sources are insufficient to decide whether the step is valid.

Do not flag omitted routine details, compressed arguments, or "analogously" steps when the omitted reasoning is recoverable and correct. For every defect, identify its smallest exact location, explain its downstream dependency, and classify any proposed repair as one of:

- Verified repair: supply enough reasoning to verify that the repair works throughout every affected use.

- Plausible repair only: describe the possible repair but do not treat it as established.

- No repair supplied.

Assign the overall proofs status by the following priority:

1. Contains incorrect or incomplete proofs, if at least one proof is Incorrect as written or Incomplete as written.

2. Contains unverified proofs, if there is no proved incorrectness or incompleteness but at least one material proof is Not able to verify.

3. Correct, if all audited proofs are Correct and complete, apart from any typographical or minor formal findings allowed by Part 4.

PART 3 — NOVELTY OF THE MAIN STATEMENTS

This is a one-sided, evidence-only check. Evaluate only central results. Report a result only when a verifiable primary source, publicly available before the earliest public version of the paper that contains the result, proves the same statement up to a change of notation, or when the result follows directly and immediately from such an earlier theorem.

For each non-novelty finding, provide the earlier source, its public date, the exact theorem or proposition, and an explicit hypothesis-and-conclusion mapping. A later source cannot establish non-novelty. Do not flag a result merely because an easier proof exists or because it follows through a nontrivial argument. Do not flag a result that the paper itself explicitly presents as known, a survey item, or an alternative proof.

Mention only statements that meet this non-novelty threshold. Say nothing about statements for which no such evidence was found: do not certify novelty, list unsuccessful searches, or add statement-level "no prior source found" entries. If the list is empty, the section may say only "No non-novelty findings."

PART 4 — TECHNICAL AND EVIDENTIARY RULES

1. Criticism must never be overstated. Call a statement incorrect, a proof incorrect or incomplete, or a result non-new only when strong formal evidence supports that exact judgment. Otherwise use Not able to verify where that outcome exists, or remain silent in the novelty section.

2. Review a specified paper version. Give exact page, theorem, equation, or proof locations; restate relevant quantifiers and hypotheses; and check domains, endpoints, parameter ranges, constants, and dependencies explicitly. Apply a defect only to the regimes and downstream results that actually depend on it.

3. Immediate-consequence closure: when deciding whether a conclusion is supported, treat the argument as including every immediate formal consequence of facts established earlier in the paper and available at that point. An immediate formal consequence is a local, mechanically checkable inference using only definitions already in force, elementary logic, direct substitution or renaming, weakening of an inequality or set inclusion, or a monotonicity or symmetry property explicit in a definition or already proved.

4. Such an inference must introduce no new lemma, estimate, construction, case analysis, limiting or compactness argument, external result, or new issue of uniformity or parameter dependence. Check the direction of monotonicity and the dependence of every threshold or constant explicitly. Do not exchange pointwise and uniform conclusions, change exceptional sets, interchange quantifiers or limits, or extend an endpoint under this rule unless the required fact was already established.

5. If the claimed conclusion follows after immediate-consequence closure, it is fully supported. Do not report a gap, unsupported statement, minor formal correction, or recommendation to add an explanatory sentence, and do not mention the suppressed item in the report. This suppression does not apply to a genuine typographical error as defined below, because a typo is a literal notation defect that still requires a textual correction. For example, if $P(\mathrm{delta})$ is proved for every sufficiently small $\mathrm{delta} > 0$ and P is immediately monotone in the required direction, then the claim that $P(\mathrm{delta})$ holds for every $\mathrm{delta} > 0$ requires no correction; the omitted monotonicity step is exposition rather than an audit finding.

6. Immediate-consequence closure permits reconstruction of an omitted inference; it does not permit silent alteration of the printed domain, hypotheses, or quantifiers of an intermediate statement later invoked outside its stated scope. If formal validity requires changing the text of that statement or its stated range, report the appropriate finding even when the repair is easy. Thus a result stated only for $t > 0$ and subsequently applied at $t = 0$ remains a formal scope mismatch unless the endpoint case was separately established before the application.

7. Apply this mandatory gate before recording any adverse, unverified, typographical, or minor formal finding: (a) identify the exact assertion or inference alleged to be defective; (b) reconstruct the strongest conclusion following from the preceding argument after all admissible immediate formal consequences are added; (c) identify the specific defect that remains — a formally demonstrated falsehood, a concrete nontrivial unresolved proof obligation, or a genuine domain, hypothesis, quantifier, or notation mismatch requiring a textual correction; and (d) state the evidence and minimal repair. If no specific defect remains, or if the only possible addition would be explanatory, suppress the finding entirely. Use Not able to verify only when a precise, nontrivial unresolved obligation can be identified.

8. A typographical error is an incorrect symbol, index, exponent, sign, variable name, or notation mismatch whose unique intended correction is mechanically determined from the surrounding text and does not alter the mathematical argument. Report it in yellow as Typo, with the printed text, correction, exact location, and reason it is harmless. It does not lower an overall status.

9. A minor formal correction is a boundary, endpoint, or displayed parameter-range defect that can be repaired consistently in every affected statement by a local change, without a new argument, without invalidating any related result or application, and without creating another substantive defect. Report it in yellow as Minor formal correction, with the same details. It does not lower an overall status.

10. Do not use either minor category if more than one materially different repair is possible; if the repair changes the substance or scope of a central result; if an excluded case is used later; if the correction fails to propagate consistently; or if a new mathematical idea is required. In such cases use the strongest substantive classification actually supported by evidence.

11. Write every mathematical expression as valid, compilable LaTeX. Use `$...$` for inline mathematics and `$$...$$` for displayed mathematics, with balanced delimiters and braces. Do not leave raw LaTeX commands outside math delimiters.

12. Separate theorem truth from the correctness of the printed proof. A theorem can be Correct in Part 1 because of a fully verified independent proof while its printed proof is adverse in Part 2. Conversely, a defective proof alone never licenses an Incorrect theorem classification.

Organize the report under Parts 1–3 and apply Part 4 throughout. Do not add editorial commentary, scores, rankings, recommendations, or a list of suppressed observations.

IN-DEPTH SOURCE EVALUATION — FOCAL PAPERS ONLY

Apply this supplement only when the audit scope is explicitly marked focal-in-depth. Do not apply it to ordinary audits of prerequisite papers.

Evaluate whether every external result materially used by the focal paper is both correctly invoked and sufficient for the exact downstream claim. Trace each such use to the exact cited source version represented in the dependence graph. Check the cited statement's hypotheses, conclusion, quantifiers, parameter ranges, and any translation of notation. Also check completeness: identify a missing proof-critical source only when a concrete step in the focal paper requires an external result that is neither proved there nor supplied by the represented sources.

Report this assessment as a fourth dimension titled Sources, after Statements, Proofs, and Novelty. Use exactly one overall status:

- Sources correct and complete: every proof-critical external input checked is applicable and sufficient, and no missing proof-critical source was identified.

- Contains unverified source use: no incorrect or incomplete source use was established, but at least one material source obligation could not be verified from the exact available versions.

- Contains incorrect or incomplete source use: at least one cited result is inapplicable or insufficient as used, or a concrete proof-critical source is missing.

Do not report citations used only for background, comparison, attribution, examples, or literature review. Do not turn this category into a bibliography audit. Apply the same evidentiary threshold, immediate-consequence closure, location precision, repair discipline, and LaTeX rules as the standardized audit prompt.

END OF REPORT

Each claim in this prototype report remains open to independent challenge and revision.