Reframing the Yang-Mills Mass Gap:
Prime Exclusion Lattices, Dimensional Inversion, and Systemic Inertia

by M. PanXnubis A. Sh. Gaia Ladrieh
9/30/25

Executive Summary

The Yang-Mills mass gap problem is one of the deepest open challenges in mathematical physics. At its heart lies the question: why do non-Abelian gauge fields, which mediate the strong nuclear force, not allow arbitrarily low-energy excitations, but instead exhibit a discrete "mass gap"?

The traditional approach formulates this in terms of Euclidean correlators: proving their exponential decay at large distances would establish the existence of a nonzero mass gap. Despite decades of work, no rigorous proof has emerged.

This contribution is not a final proof, but a new framework for constraining and navigating the problem space. By mapping Yang-Mills correlator behavior to the prime exclusion lattice and its higher-dimensional projections, we reframe exponential decay as a recursion phenomenon and the emergence of mass as an inversion phenomenon. This reframing identifies "jump cost" between primes as the key metric for distinguishing decay from persistence, narrowing solution space and creating computational footholds.

This insight also connects the physics of the mass gap to broader systemic transitions – whether in markets, computation, or social systems – making it valuable both to mathematicians seeking rigor and to strategic funders seeking leverage.

Restatement of the Problem in Physics Terms

Yang-Mills theory describes gauge fields with non-Abelian symmetry groups (e.g. SU(2), SU(3)). These fields govern the dynamics of quarks and gluons, yet are observed to confine – no free gluon has ever been seen.

The Clay Millenim statement asks for a proof that Yang-Mills theory on ℝ^4 exists as a quantum field theory with a nonzero mass gap. Concretely, the Euclidean correlator of gauge-invariant operators should decay exponentially with distance, ensuring that excitations cannot exist at arbitrarily low energies.

The obstacle is bridging between:

- the perturbative/UV domain (where calcuations are tractable), and
- the nonperturbative/IR domain (where confinement and mass generation appear).

Novel Framework: Prime Exclusion Lattices and Dimensional Inversion

My proposal begins from a simple but powerful analogy:

- Primes function as the skeleton of syntax in mathematics – marking indivisible constraints.
- The prime exclusion lattice encodes what is possible vs. prohibited, forming the "boundary conditions" of any syntactic system.
- Mapping this into higher dimensions, the 7D lattice degenerates toroidally, producing 5D contraint fields. The 4D physical space we experience corresponds to the "holes" (faces) of this lattice structure.

Within this framework:

- An operator injection (excitation) inside an existing prime exclusion field cannot bridge to a new lattice. It

therefore recurses back and decays exponentially.
- A successful jump to the next prime lattice requires surpassing the jump cost, an energy threshold analogous to the mass gap. If surpassed, recursion becomes inversion – momentum is gained, and the excitation persists.

Thus, the mass gap corresponds exactly to the minimal jump cost between prime exclusion lattices mapped into the 4D correlator field. This aligns with the physical intuition that confinement prevents sub-threshold excitations from escaping.

Attack Vetors and Verification Points

This framework suggest several concrete points of entry:

- A. Numerical Toy Models: Weighted Laplacian models reproduce exponential decay and reveal critical inflection points (A_c). These act as simplified analogs of the mass gap, where recursion transitions to inversion.
- B. Prime Exclusion Mapping: The 2310 prime wheel provides an accurate scaffold for exclusion fields. These can serve as skeletons for permissible gauge configurations, narrowing the solution space.
- C. Jump Cost Metric: By explicitly computing jump costs between successive primes (e.g. 173 → 181), we observe discrete thresholds. These serve as prototypes for bounding the Yang-Mills mass gap from below.
- D. Renormalization Link: The semantics-syntax bridge maps naturally onto renormalization group flows, where higher-dimensional semantics constrain lower-dimensional syntax. The mass gap then appears as the cost of crossing dimensional strata.

Together, these points form a verification locus – a structured way to constrain and reduce the Yang-Mills problem without brute force.

Implications and Applications

1. Physics: This approach offers a new foothold for bounding and ultimately proving the existence of the mass gap, by linking discrete prime lattices to continuous field correlators.
2. Complexity Science: The recursion vs. inversion dynamic models how systems resist or assimilate operator injections – directly applicable to market shocks, AI training dynamics, and geopolitical transitions.
3. Investment Value: For funders, this provides a general-purpose transition framework – a way to identify when systems will decay bck into inertia versus when they will invert into new stable regimes. Such foresight translates directly into strategic advantage.
4. Mathematics: By reducing the Yang-Mills problem to jump cost verification across constrained lattices, we reframe it as a more tractable question of boundary conditions and exponential decay, offering mathematicians a narrowed proof trajectory.

Closing Statement

I am not claiming a completed proof of the Yang-Mills mass gap. What I'm presenting is a new conceptual and mathematical scaffold that narrows solution space, identifies verifiable footholds, and reframes the exponential decay problem in terms of discrete jump costs across prime exclusion lattices.

This reframing is rigorous enough to be pursued mathematically, and general enough to be applied strategically. It represents not just progress toward one of the deepest unsolved problems in physics, but also a universal framework for understanding systemic inertia, inversion, and transformation.

Appendix A: Technical Proposal

Theorem – Prime Lattice Exponential Decay Criterion

Let *P* (sub *n*) denote the *n*-th prime and let $\mathcal{E}$ (*P* (sub *n*)) denote the exclusion lattice generated by *P* (sub *n*). Definte a gauge-invariant excitation (operator injection) $\mathcal{O}$ localized within $\mathcal{E}$ (*P* (sub *n*)). Then:

1. If the injected force $\mathcal{F}$ satisfies

   $\mathcal{F}$ < Δ(*P* (sub *n*), *P* (sub *n* + *1*), where Δ(*P* (sub *n*), *P* (sub *n* + *1*) = *P* (sub *n* + *1*) – *P* (sub *n*) is the prime jump cost, then the correlator of $\mathcal{O}$ exhibits exponential decay:

< $\mathcal{O}$(*x*)$\mathcal{O}$(*y*)> ‚ e^-α|*x*-*y*|, α < 0.

2. If $\mathcal{F}$ ≥ Δ(*P* (sub *n*), *P* (sub *n* + *1*), then the excitation inverts into the next lattice, $\mathcal{E}$ (*P* (sub *n* +*1*)), and does not decay exponentially.

Sketch of Proof Strategy

- Step 1 (Discrete-Continuous Mapping):
  Construct the prime exclusion lattice as a discrete skeleton. Map this into a continuous field by embedding in a 7D toroidal framework, with 4D correlators corresponding to "holes" in the 5D faces.
- Step 2 (Jump Cost as Energy Gap):
  Show that Δ(*P* (sub *n*), *P* (sub *n* + *1*) acts as a lower bound on the minimum spectral gap for excitations confined to $\mathcal{E}$ (*P* (sub *n*).
- Step 3 (Exponential Decay):
  Use standard spectral theory: if the lowest eigenvalue exceeds zero, the correlator decays exponentially. Identify the eigenvalue with the prime gap threshold.
- Step 4 (Inversion Condition):
  If injection exceeds Δ(*P* (sub *n*), *P* (sub *n* + *1*), show that recursion fails and excitation persists in the new lattice – corresponding to the lack of exponential decay.

Connection to Yang-Mills Mass Gap

- In Yang-Mills theory, the mass gap is the minimal energy of nontrivial excitations.
- In this framework, this corresponds to the minimal prime jump cost across all embeddings:
  m (sub *gap*) = inf (sub *n*)Δ(*P* (sub *n*), *P* (sub *n* + *1*).
- This links the nonperturbative spectral gap in Yang-Mills directly to the arithmetic structure of primes, providing both a conceptual model and a possible route for bounding the gap.

Conjecture

The Yang-Mills mass gap is equivalent to the existence of a uniform positive lower bound for prime jump costs under dimensional inversion embeddings:

∃ (sub ε) > 0 such that Δ(*P* (sub *n*), *P* (sub *n* + *1*) ≥ ε ∑*n* under mapping

This reframes the Clay problem as a bounded gap problem within the prime-exclusion lattice structure.

Pseudocode: Prime-Exclusion Lattice Spectral Gap Model

INPUT:

 N # size of integer chain (e.g. N = 1000)

 Pset # set of primes to include in exclusion lattice (e.g. {2, 3, 5})

```
 w # exclusion weight (scalar, or function of prime)

STEP 1: Initialize base Laplacian operator L
 - Create N x N zero matrix L
 - For i from 1 to N:
 - If i > 1:  L[i,i-1] = -1
 - If i < N:  L[i,i+1] = -1
 - L[i,i] = degree of node (1 or 2 in 1D chain)

STEP 2: Build prime-exclusion potential V
 - Initialize diagonal matrix V of size N x N
 - For i from 1 to N:
 - Set penalty = 0
 - For each p in Pset:
 - If i is divisible by p:
 penalty = penalty + w  # (or w(p) if non-uniform)
 - V[i,i] = penalty

STEP 3: Form full operator
 H = L + V

STEP 4: Compute eigenvalues of H
 - eigvals = Eigenvalues(H)
 - Sort eigvals in ascending order

STEP 5: Extract spectral gap
 - gap = smallest positive eigenvalue (after the zero mode)

OUTPUT:
 gap
 # (Optionally: plot eigenvalues vs index,
 # or track gap as Pset and w vary)
```