Geometric Monism: Topological Structure of Scattering Processes and a Geometric Interpretation of Gauge Redundancy

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Abstract

Modern Quantum Field Theory (QFT) describes particle interactions through scattering amplitudes derived from perturbative expansions of gauge theories. While highly successful, these calculations often involve large intermediate expressions with substantial gauge redundancy. Recent developments, including geometric reformulations such as the amplituhedron, suggest that scattering amplitudes may admit simpler underlying structures.

The present work explores whether scattering processes can be interpreted geometrically within the Geometric Monism (GM) framework. In GM, particles are modeled as torsional standing-wave structures in a 5-dimensional manifold governed by the Planck Stiffness $\kappa_T = c^4/G$, and interactions are modeled as localized topological junctions.

Within this interpretation, helicity configurations and certain constrained scattering processes are described as geometric combinations of torsional axes rather than sums over large perturbative expansions. The analysis suggests that aspects of gauge redundancy may reflect the projection of continuous geometric structure into perturbative formalisms. Additionally, gravity is interpreted as macroscopic elastic strain of the manifold, motivating a geometric perspective complementary to particle-exchange models. These results are presented as interpretive and conceptual, not as replacements for the Standard Model or QFT.

Keywords: Geometric Monism; Quantum Field Theory; scattering amplitudes; amplituhedron; gauge redundancy; torsion; 5D geometry; gravitational strain.

1 Introduction

Quantum Field Theory describes interactions through scattering amplitudes computed using perturbative expansions and Feynman diagrams. While these methods are predictive, they often involve large intermediate expressions that cancel extensively due to gauge redundancy.

Recent developments such as geometric formulations of scattering amplitudes [2] indicate that simpler underlying structures may exist. This motivates the exploration of alternative representations of interactions.

This paper investigates whether scattering processes admit a complementary geometric interpretation within the Geometric Monism (GM) framework.

Interpretive scope. This work does not replace QFT or scattering-amplitude methods. Instead, it explores whether certain amplitude structures can be interpreted as projections of underlying geometric configurations.

2 Topological Interpretation of Interacting Entities

In GM, particles are modeled as localized torsional structures described by the 5D tensor:

$$T^A{}_{BC} \tag{1}$$

Within the Anti-Axial constraint, the operational microscopic sector contains 40 degrees of freedom.

Relevant structures:

- Fermions: 4π standing waves
- Gluons: $T^4{}_{\mu\nu}$ torsional axes
- Photons: $T^0{}_{i4}$ propagating modes

3 Scattering as Topological Junctions

In QFT, scattering amplitudes represent sums over interaction histories. In GM, interactions are interpreted as localized geometric junctions between torsional structures.

Helicity corresponds to orientation of torsional twist:

- Right-handed twist: $+1$
- Left-handed twist: -1

For constrained configurations (e.g. collinear limits), conservation of winding number provides a geometric consistency condition:

$$\sum w_{\text{in}} = \sum w_{\text{out}}. \tag{2}$$

This provides a simplified geometric interpretation of certain amplitude structures.

3.1 Phase Compatibility at Topological Junctions

Wave phenomena are characterized by phase, and interaction between waves depends on their relative phase relationships. Within the GM framework, torsional entities possess an intrinsic phase structure associated with their standing-wave configuration.

When two or more such entities form an interaction junction, the resulting configuration must satisfy local compatibility conditions. In particular, the participating torsional structures must admit a consistent phase closure across the junction region. Configurations that fail to satisfy this condition do not form stable interaction channels.

This provides a geometric interpretation of why only certain interaction outcomes are realized. Rather than arising from a summation over virtual intermediate states, the admissible channels are those for which the connected wave topology supports consistent local phase matching.

This interpretation does not replace the probabilistic structure of quantum theory. Instead, it offers a geometric perspective in which probability conservation reflects the finite set of phase-compatible configurations available to the interacting system.

4 Geometric Perspective on Gauge Redundancy

In perturbative QFT, intermediate expressions contain gauge-dependent terms that cancel in physical observables.

Within GM, this may be interpreted as arising from projecting continuous geometric structures into redundant algebraic representations. The underlying interaction may correspond to a simpler geometric configuration, while the perturbative expansion introduces auxiliary degrees of freedom.

This interpretation is consistent with geometric reformulations of scattering amplitudes, such as the amplituhedron [2]. In that framework, scattering amplitudes can be computed from a single geometric object rather than from a sum over Feynman diagrams, without explicit reference to virtual particles or gauge-dependent intermediate quantities. This demonstrates that the conventional diagrammatic expansion contains substantial non-physical redundancy, and that the physically relevant content of the interaction can be encoded in a more compact geometric representation.

While the amplituhedron is formulated as an alternative mathematical description within QFT rather than as an ontological model, its structure supports the broader interpretation adopted here: that scattering amplitudes may be understood as projections of underlying geometric configurations, rather than as literal histories of particle exchange.

4.1 Illustrative Comparison of Representational Complexity

It is instructive to compare how certain constrained scattering configurations are represented in different formalisms.

In perturbative QFT, even when the final amplitude admits a compact expression (for example in helicity-selected or collinear limits), intermediate calculations may involve large algebraic structures, cancellations, and gauge-dependent contributions. Modern amplitude methods have shown that these results can often be written in significantly simplified forms, indicating that the underlying physical content is more compact than the diagrammatic expansion suggests [1, 2].

Within the GM framework, this compression is interpreted geometrically. In particular:

- **Helicity as torsional handedness:** a positive-helicity mode corresponds to a right-handed torsional twist, and a negative-helicity mode to a left-handed twist.
- **Collinearity as axis alignment:** when interacting modes are approximately collinear, their associated torsional structures are aligned along a common geometric axis in the 5D manifold.
- **Topological conservation:** interaction regions are modeled as localized torsional junctions, constrained by conservation of winding number. In collinear configurations, contributions combine along the shared axis, allowing effective addition or cancellation of winding without geometric inconsistency.

This does not constitute a derivation of scattering amplitudes within GM. Rather, it provides an interpretive framework in which certain observed simplifications—especially in special kinematic limits—are understood as consequences of an underlying finite topological structure.

From this perspective, different computational approaches may be viewed as alternative representations of the same physical content, with varying degrees of algebraic redundancy. The GM framework suggests that, in appropriate limits, this content admits a compact geometric description.

5 Standard Model Completeness in GM (Falsification Criterion)

A further implication of the GM framework is that the Standard Model particle classification is not open-ended in the usual ontological sense. Within GM, stable fundamental particles correspond to the finite set of torsional entity classes permitted by the constrained 5D geometry.

This does not preclude the observation of resonances, composite states, bound systems, or effective excitations. However, such phenomena are interpreted as emergent or composite structures within the existing torsional framework.

Falsification Criterion: The GM framework would be falsified by unambiguous experimental evidence for a new fundamental particle that cannot be interpreted as a composite, resonance, or effective excitation of the existing Standard Model sector and cannot be embedded within the finite torsional entity classes permitted by the GM geometry.

6 Limitations

This work is conceptual and interpretive. It does not:

- derive full scattering amplitudes,
- replace perturbative QFT,
- or provide a complete theory of quantum gravity.

7 Conclusion

This paper has explored a geometric interpretation of scattering processes within the GM framework.

The results suggest that certain amplitude structures may correspond to simpler topological junctions, and that gauge redundancy may reflect projection from continuous geometry.

These interpretations complement, rather than replace, standard QFT.

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References

[1] Parke, S. J., & Taylor, T. R. (1986). An amplitude for n-gluon scattering. *Physical Review Letters*, 56(23), 2459–2460.

[2] Arkani-Hamed, N., & Trnka, J. (2014). The Amplituhedron. *Journal of High Energy Physics*, 2014(10), 30.