Renormalization as a Boundary Operation in the Quantum Field Theory of the Standard Model

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Abstract

Renormalization is one of the most successful technical procedures in modern physics. It renders quantum field theories predictive by systematically absorbing divergences into redefined parameters. Despite its practical indispensability, its conceptual status remains unclear: renormalization stabilizes calculations without explicitly stating which kind of boundary assumption is thereby enacted.

This paper argues that renormalization should not be understood primarily as a technical stopgap, but as an implicit boundary operation. Within the MNO (Minimal-Non-Object) approach, it is read as a formal response to integration limits: divergences appear not as mere calculational errors, but as signals of a formalism whose local predictive power can be secured only through active boundary management.

The proposed reading neither alters the mathematical formalism nor the practical application of renormalization. It does, however, make visible that the Standard Model operatively manages its own boundary conditions without explicitly conceptualizing them. Renormalization is thus reclassified as a stabilizing, but not world-constituting, operation.

(This paper is an interface text. The author's primary research corpus employs an autistic, non-linear, rhythmically recursive writing mode that cannot be fully preserved in academic English without structural loss of epistemic function.)

Scope Statement

This paper:

- proposes no new physics,
- modifies no renormalization techniques,
- introduces no new degrees of freedom or entities,
- provides no additional empirical assumptions and no new predictions.

It understands itself as conceptual boundary work aimed at clarifying what renormalization does—and what it deliberately does not do.
Its concern is the conceptual status determination of an already established practice.

The MNO approach is not systematically introduced here, but is presupposed as a conceptual framework; a detailed exposition can be found in the reference list.

This paper claims no new insight into the mathematical structure of renormalization. Its contribution lies in the conceptual explication of a boundary logic that has long been operatively effective in the practice of effective field theories, but is rarely made explicit.

1. Introduction: The Paradoxical Success of Renormalization

Renormalization is regarded as one of the greatest successes of quantum field theory. Without it, many of the most precise predictions of modern physics would not be possible. At the same time, it belongs to the conceptually most uncomfortable elements of the Standard Model formalism: divergences arise, are removed, and the result works—without it being clear what status these divergences have with respect to formalism, scales, and reality.

In practice, this problem is often bypassed. Renormalization "works," and the question thus appears settled. This paper intervenes precisely at this point. It does not ask whether renormalization is legitimate, but which boundary assumption it operatively implements: which claims to global integrability are tacitly abandoned in order to preserve local predictive power?

2. Divergences as Boundary Phenomena

Divergences arise where integrations across scales can no longer be stably controlled within a given formalism—typically in the ultraviolet structure and in the handling of regulators at their limits. In the standard reading, they are treated either as artifacts of an incomplete formalism or as indications of new physics beyond certain energy scales.

The MNO approach proposes an alternative, minimalist reading:

Divergences are not errors, but boundary signals.

They mark points at which structure can no longer be treated as "straightforwardly integrable" without endangering the predictive power of the model.

3. Renormalization as Active Boundary Management

Renormalization responds to these boundary signals not by explaining divergences, but by formally neutralizing them: parameters are redefined, contributions are absorbed, and scales are organized in such a way that predictions remain stable within a given domain of validity.

From this perspective, renormalization is not an ontological operation, but a stabilizing one. It secures local physics by limiting claims to global integrability—it manages the point at which "the model" must cease to treat itself as ontologically closed.

Renormalization suppresses emergence beyond the stability threshold without negating it.

4. MNO: Renormalization Without Ontological Claim

Within the MNO approach, renormalization is not read as an indication of hidden entities or fundamental structures, but as a response operation to structural overload.

This means:

- renormalized quantities are not ontological carriers,
- but effective response parameters within a limited domain of validity.

This is not an instrumentalist argument in the sense of "merely fictitious," but a status determination: renormalized parameters are really effective within their conditions of stability, yet they do not ground a world ontology beyond those conditions.

Renormalization stabilizes physics; it does not constitute a world.

5. Relation to Effective Field Theory

Effective field theory has already operationally accepted this boundary logic. It explicitly relinquishes claims to global validity and works with clearly defined scale restrictions.

This paper does not read EFT as a merely pragmatic approximation, but as an implicit acknowledgment of an ontological boundary: EFT makes explicit what renormalization enacts implicitly—the separation between stable local describability and global ontological closure.

6. Consequences

The reading proposed here has no immediate calculational consequences. It does, however, alter the conceptual status of renormalization:

- Renormalization explains no reality.
- It stabilizes describability.
- It marks, without naming it, where object ontology ends.

In this way, a tacit category mistake is avoided: the equation of formal stability with ontological grounding. From this perspective, debates on naturalness and fine-tuning appear in part as symptoms of an inflated ontological demand placed on a formalism that is structurally designed around domains of validity.

7. Conclusion

Renormalization is not a deficiency of physics, but an indication of its boundary. It enables precise predictions by actively limiting claims to integration. The MNO approach renders this boundary operation visible without altering the physical formalism.

Renormalization stabilizes physics by suspending ontological closure.

This paper is situated in the context of:

Speed, T. (2025). MNO and Ontological Recurrence: A Non-Representational Account of Quantum Measurement and Conscious Experience (Version 1). Zenodo. https://doi.org/10.5281/zenodo.17913823

Speed, T. (2025). Orch-OR with Recurrence: A Minimal Dynamical Condition for When Objective Reductions Yield Conscious Experience (1 English). Zenodo. https://doi.org/10.5281/zenodo.17942531

Speed, T. (2025). Operatoric Cognition: Pre-theoretical Structural Invariance as the Basis of Autistic Intelligence (3 English). Zenodo. https://doi.org/10.5281/zenodo.17897109

Speed, T. (2025). The Gap as a Condition - Pre-Ontological Operatorics and the Primacy of Response (2 English). Zenodo. https://doi.org/10.5281/zenodo.18015885 2

Speed, T. (2025). From Objects to Responses - On the Loss of Ontological Sovereignty in Contemporary Physics (Version 1). Zenodo. https://doi.org/10.5281/zenodo.18017629

Speed, T. (2025). Seinsverschiebung (Shift of Being) as a Pre-Ontological Category - On the Incompatibility of Existence and Understanding in Modern Regimes of Stabilization (2 English). Zenodo. https://doi.org/10.5281/zenodo.18007628

Speed, T. (2025). The Constructed Observer - World-Formation Beyond Representation - Why Perception Is Not Representation, but a Structural Achievement (2 English). Zenodo. https://doi.org/10.5281/zenodo.18006170

Speed, T. (2025). Dark Energy as an Emergent Residuum - A Minimal Operator-Based Interpretation within an MNO Framework (2 English). Zenodo. https://doi.org/10.5281/zenodo.18015172

Speed, T. (2025). Measurement Without an Observer - On the Spatial Stabilization of Determinacy in the MNO Model (Version 1). Zenodo. https://doi.org/10.5281/zenodo.18020588