Global Spectral Theory of Everything

Version 2: Scope, Validation, and Limits

Author: Grzegorz Olbryk
Affiliation: Independent
Contact: g.olbryk@gmail.com
Repository: https://github.com/golbryk/global-spectral-toe

Abstract

I present the corrected second version of the Global Spectral Theory of Everything (TOE), a background-independent framework in which physical structure emerges from global spectral properties of a relational system rather than from local dynamics on a predefined spacetime.

This version explicitly incorporates falsification and validation results, most notably a systematic Random Matrix Theory (RMT) analysis. These tests demonstrate that the fundamental vacuum and minimal excitation operators exhibit intermediate spectral statistics between Poisson and GOE ensembles. Consequently, interpretations of the framework as a direct effective theory of hadrons or other strongly chaotic many-body systems are falsified.

The theory remains internally consistent as a fundamental framework. The complete axiomatic and mathematical formulation is provided in companion LaTeX sources available in the public repository.

1. Motivation

A central challenge of theoretical physics is to construct a unified description of mass, time, interactions, and spacetime without assuming a predefined background, local Hamiltonians, or quantization postulates.

> *To construct a logically closed, background-independent framework in which physical structure emerges from global spectral properties.*

This work does not aim to directly reproduce low-energy phenomenology. Its claims are restricted to the fundamental level.

2. Conceptual Overview

2.1 Relational Network

The theory starts from a finite relational network. No spacetime, metric, causal structure, or local dynamics are postulated.

2.2 Global Transport Operator

A single global transport operator T is defined as an average over smeared closed transport loops. Its spectrum $\{\lambda_n\}$ encodes all physical structure.

In this perspective, geometric information is not fundamental but may emerge from spectral properties. In particular, effective geometric dimensionality can be viewed as a function of spectral density or asymptotic eigenvalue growth (Weyl-type behavior), although no explicit derivation is attempted here.

3. Core Mathematical Structure

3.1 Spectral Ontology and Sector Structure

$$\lambda_n^{(a)} > 0$$

The sector index (a) labels stable spectral clusters or block structures emerging from the global operator rather than independent operators. These sectors reflect internal relational organization of the spectrum and are not assumed a priori.

3.2 Logarithmic Spectra

$$\ell_n^{(a)} = \log \lambda_n^{(a)}$$

3.3 Global Spectral Functional

$$\mathscr{L} = \Sigma_{a,b}\, w_{ab}\, \Sigma_{m,n}\, (\ell_m^{(a)} - \ell_n^{(b)})^2$$

3.4 Vacuum Condition and Fixed Points

$$\delta\mathscr{L}/\delta\ell_n^{(a)} = 0 \Rightarrow c_a^* = \langle \ell^{(a)} \rangle$$

3.5 Emergent Mass Scale

$$m \sim |c_a^* - c_b^*|$$

3.6 Emergent Time

$$\varphi_{n+1} = T\, \varphi_n$$

3.7 Spectral Entropy

$$S = -\, \Sigma_i\, p_i \log p_i$$

4. Structural No-Go Results

- **No local mass:** local subregions do not exhibit spectral gaps.
- **No local time:** local spectra remain unit-modulus.
- **No fundamental ergodicity:** global relational constraints limit chaotic mixing.

5. Random Matrix Theory (RMT) Validation

Random Matrix Theory provides a stringent test of spectral universality. RMT analyses were performed on excitation operators constructed as representative realizations compatible with the axioms of the theory. These operators should not be interpreted as unique consequences of the global spectral functional.

Across system sizes and coupling strengths, the spectra consistently occupy an intermediate statistical regime between Poisson and GOE ensembles. Here the term *pseudo-integrable* is used in a statistical sense to denote such intermediate behavior, without implying equivalence to known pseudo-integrable classical systems.

The present analysis is based on spacing-ratio statistics without explicit unfolding. While this statistic is relatively robust against global density variations, refined unfolding-based analyses are left for future work.

The observed intermediate statistics suggest the presence of hidden structural or topological constraints in the underlying relational network, which can suppress full thermalization and universal quantum chaos at the fundamental level.

6. Predictive Constraints

While the present framework does not yield direct low-energy predictions, it imposes strong constraints on admissible effective theories. In particular, the framework is incompatible with fully chaotic fundamental dynamics in the sense of universal random-matrix universality at the most basic level.

7. Scope and Limits

This theory is:

- background-independent,
- axiomatically closed at the fundamental level,
- explicitly falsifiable.

This theory is not:

- a phenomenological hadron model,
- a replacement for QCD or EFTs,
- a framework guaranteeing universal quantum chaos.

8. Documentation and Reproducibility

The complete mathematical formulation, including axioms, derivations, and numerical fixed points, is provided in the LaTeX source `global_spectral_toe_core.tex` in the public repository:

https://github.com/golbryk/global-spectral-toe

All numerical tests, raw logs, and figure-generation scripts used in the RMT analysis are included in the repository to ensure reproducibility.

9. Citation

If you use or reference this work, please cite:

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10. Keywords

Spectral theory, background independence, relational ontology, random matrix theory, pseudo-integrability

11. Conclusion

This Version 2 corrects earlier interpretations in light of explicit falsification tests. While universal quantum chaos does not emerge at the fundamental level, the theory remains internally consistent as a background-independent foundational framework with clearly stated limits and methodological constraints.