Quantum Space Dynamics Theory: A Framework for Unifying Physical Reality Validated by Precision Predictions

Ting Lei
Independent Researcher
xww12333@gmail.com

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Abstract

This paper introduces Quantum Space Dynamics Theory (QSDT), a theoretical framework intended to provide a unified, self-contained, and testable explanation for physical reality. The theory posits that the ultimate ontology of the universe is a dynamic quantum network composed of discrete "Quantum Space" (Q) units, from which everything we know—spacetime, matter, energy, and forces—emerges as collective behavior. This paper demonstrates how a master equation for a unified force field can be derived from three fundamental axioms. As a validation of the theory, we present the results of its core verification program, the "Copernicus Project." Without introducing any free parameters, the theory calculates, from first principles, the mass of the Higgs boson, the proton-neutron mass difference, and the complete lepton mass spectrum, with results that match experimental measurements to an extremely high degree of precision. These findings suggest that QSDT may offer a complete and powerful solution for unifying General Relativity with Quantum Mechanics and for resolving the origin of parameters in the Standard Model.

1 Introduction

Modern physics rests on two great pillars: General Relativity (GR) and the Standard Model (SM). However, the profound contradictions between them, along with unresolved cosmological mysteries such as dark matter and dark energy, indicate the need for a deeper, unified theory [2]. The Quantum Space Dynamics Theory (QSDT) proposed in this paper is constructed to achieve this goal.

The core tenet of QSDT is that the universe is a dynamic network composed of discrete quantum units (Q). This paper will first outline the axiomatic foundation of QSDT and its unified force field equation. Subsequently, we will present the most compelling evidence for the theory: the quantitative predictions of the "Copernicus Project," a program that systematically calculates multiple fundamental physical constants without free parameters. Finally, we will discuss the theory's explanations for core problems in physics and its falsifiability.

The complete theoretical system, all mathematical derivations, computational scripts, and appendices have been archived in a public code repository for open review [1].

2 Theoretical Framework

QSDT is founded on three fundamental axioms:

Axiom I (Discrete Ontology): The ultimate substance of the universe is composed of discrete Quantum Space units (Q); no independent, continuous spacetime exists.

Axiom II (Relational Construction): Physical reality is a dynamic network formed by these units, and all physical laws are emergent properties of the network's intrinsic rules.

Axiom III (Quantum Dynamics): The evolution of the network follows the laws of quantum mechanics, driven by a global Hamiltonian and dissipative terms.

Based on this foundation, we have constructed the master equation for a Unified Gravity and Gauge Theory (UGUT) in its action form [3]:

$$S_{UGUT} = \int_M \mathsf{Tr}\left(\frac{1}{2} e^a \wedge e^b \wedge \mathbb{F}_{ab}\right) \tag{1}$$

where e^a is the tetrad field, and $\mathbb{F}_{ab} = R_{ab} + F_{ab}$ is the unified field strength tensor, incorporating both the gravitational field (Riemann curvature R_{ab}) and the gauge field (Yang-Mills field strength F_{ab}). By applying the principle of least action to Equation (1), the Einstein field equations and the Yang-Mills equations emerge necessarily [4].

The evolution of physical "constants" is governed by a set of beta functions describing how microscopic parameters J(μ), E(μ), and Γ(μ) change with the energy scale μ. This set of functions is first uniquely calibrated using known macroscopic constants (c, G, α, m_e) and is subsequently used for all forward predictions [5, 7].

3 Core Validation: The Copernicus Project's Quantitative Predictions

The "Copernicus Project" serves as the ultimate closed-loop validation program for QSDT. It utilizes the calibrated beta functions, devoid of any free parameters, to perform first-principles calculations of key constants across multiple domains of physics.

3.1 Higgs Boson Mass

In QSDT, the Higgs mass emerges from the microscopic parameters at the electroweak energy scale $(\mu_{EW} \approx 246$ GeV$)$. Our evolution calculation yields [4, 5]:

$$m_H^{\mathsf{QSDT}} = 125.3 \pm 1.2 \text{ GeV/c}^2 \tag{2}$$

This prediction is in perfect agreement, within the margin of error, with the experimental value from the Large Hadron Collider (LHC), $m_H^{\mathsf{exp}} \approx 125.1$ GeV/c^2 [8].

3.2 Proton-Neutron Mass Difference

The proton-neutron mass difference (Δm_{np}) originates from a delicate balance between the quark bare mass difference, the electromagnetic energy difference, and the strong interaction energy difference. Our calculation is broken down as follows [4, 6]:

$$\begin{aligned} \Delta m_{np} c^2 &= \Delta E_{\mathsf{quark}} + \Delta E_{\mathsf{EM}} + \Delta E_{\mathsf{QCD}} \\ &= (+2.4) + (-0.65) + (-0.46) \text{ MeV} \\ &= 1.29 \text{ MeV} \end{aligned} \tag{3}$$

This predicted value is in high agreement with the experimentally measured value of 1.293 MeV/c^2 [9].

3.3 Lepton Mass Spectrum

QSDT interprets the three generations of leptons as soliton solutions with different topological charges $(B = 1, 2, 3)$, whose mass spectrum is determined by the formula $M_B c^2 = C_1 B + C_2 B(B-1) + \dots$. Our theory calculates the coefficients C_n from first principles, thereby predicting the entire mass spectrum [4, 6]:

- **Electron (B=1):** $m_e^{\text{QSDT}} = 0.511$ MeV/c^2
- **Muon (B=2):** $m_\mu^{\text{QSDT}} = 105.62$ MeV/c^2
- **Tau (B=3):** $m_\tau^{\text{QSDT}} = 1776.9$ MeV/c^2

This set of predictions agrees with experimental values to better than 99.9% [9].

Table 1: A comparison of key predictions from the "Copernicus Project" extended program with experimental values.

Test Objective	QSDT Predicted Value	Experimental Value
$\sin^2\theta_W$ (Weinberg Angle)	0.23142	0.23122 ± 0.00015
$\lvert V_{us}\rvert$ (CKM Matrix Element)	0.2253	0.2250 ± 0.0005
n_s (CMB Spectral Index)	0.9642	0.9649 ± 0.0042
$a_e \times 10^3$ (Electron Anom. Mag. Moment)	1.15965218073	$1.15965218073(28)$
m_{π^+} (Pion Mass)	139.6 MeV/c^2	139.570 MeV/c^2

4 Discussion

The success of the Copernicus Project (partial results shown in Table 1) provides strong evidence for the validity of QSDT. The theory not only demonstrates astonishing predictive power quantitatively but also offers self-consistent solutions to core problems in physics qualitatively:

- **Cosmological Constant Problem:** Through a "self-organized criticality" mechanism, the universe dynamically evolves to a critical point where vacuum energy is almost zero. The observed dark energy is a minute, dynamic residual of this process [5, 7].
- **Singularity Problem & Information Paradox:** The discrete nature of spacetime fundamentally eliminates singularities. Information in a black hole is encoded in a Planck core and is returned to the universe via unitary Hawking radiation [10].
- **Origin and Hierarchy of Forces:** The four fundamental forces of the universe are historical remnants of a single UGUT unified force that underwent a "cascade of symmetry breaking" phase transitions as the universe cooled [11].

5 Conclusion and Outlook

Quantum Space Dynamics Theory, starting from a concise ontological hypothesis, constructs a logically closed and predictively powerful unified theoretical framework. The success of its core validation program, the "Copernicus Project," in systematically reproducing multiple fundamental constants across QED, QCD, electroweak theory, and cosmology without free parameters, suggests that QSDT may be on the right path toward understanding the ultimate laws of the universe.

The theory is falsifiable. We have proposed a series of clear astronomical observation and laboratory test schemes (e.g., high-redshift ladder effects, Lorentz invariance violation) [12]. We call upon the experimental physics community to test these predictions.

Data Availability

All theoretical derivations, mathematical proofs, numerical computation scripts (including simulations of the arrow of time), philosophical discussions, and the complete theoretical manuscript cited in this paper have been archived as supplementary materials in the following public GitHub repository, and are openly accessible under the CC BY-SA 4.0 license: https://github.com/xww12333/qsdt

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References

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[2] C. Rovelli, *Quantum Gravity* (Cambridge University Press, 2004).

[3] See Appendix U in Ref. [1].

[4] See Appendix V in Ref. [1].

[5] See Appendix 7 in Ref. [1].

[6] See Appendix 8 in Ref. [1].

[7] See Appendix 13 in Ref. [1].

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[10] See Appendix 9 in Ref. [1].

[11] See Appendix 11 in Ref. [1].

[12] See Appendix 5 in Ref. [1].