Technical Supplement to TMD 3.0

Discrete Spectrum of Bulbs and the Energy Model $E(N)$

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Abstract

This technical supplement extends the ontological framework of TMD 3.0 with a quantitative model of bulb energy as a discrete function of the number of triads N. We introduce explicit forms for the stability $S(N)$ and the orientational tension $U(N)$ and derive the bulb energy in the form

$$E(N) = U(N)\, S(N)^2.$$

The discreteness $N \in \mathbb{N}$ leads to a discrete spectrum of stable orientational configurations, which can be interpreted as elementary particles. We show how the model can be calibrated to the electron and quarks, and how a "periodic table of bulbs" naturally emerges. This document serves as a technical supplement to TMD 3.0 and illustrates that the ontological triad framework can be extended with quantitative models with physical interpretation.

1 Introduction

This technical supplement extends the main TMD 3.0 document with a quantitative model describing the energy of bulbs as a discrete function of the number of triads N. While the main text of TMD 3.0 formulates the ontological framework of triads, orientation, and foliation without using physical quantities, the goal of this supplement is to show that the same ontological structure can be complemented by a simple mathematical model that generates a discrete spectrum of stable orientational defects.

The motivation for this supplement is to demonstrate that TMD is not only a qualitative description of spatial structure, but that it can be extended with quantitative models that have direct physical interpretation. By introducing the stability function $S(N)$ and the orientational tension $U(N)$, we obtain the bulb energy

$$E(N) = U(N)\, S(N)^2,$$

which leads to discrete stable values of N. These stable points can be interpreted as different types of elementary particles.

This document is conceived as a supplement to TMD 3.0, not as its replacement. The model presented here is a first approximation: it is not a final physical theory, but a demonstrative construction showing that the ontological principles of TMD naturally lead to a discrete spectrum, particle families, and the possibility of calibration to known physical energies.

The model has limitations: it uses simple analytic forms, does not include dynamics or interactions between multiple bulbs, and does not address the detailed topology of orientational defects. Nevertheless, it provides an important proof of concept that TMD can be extended with a quantitative layer consistent with the structure of observed physics.

2 Ontological Foundations (Summary from TMD 3.0)

This section briefly recapitulates the basic ontological concepts introduced in TMD 3.0. Its purpose is to make this technical supplement self-contained and to provide context for introducing the quantitative energy model of bulbs.

2.1 Triads

A triad is the elementary ontological unit of space in TMD. Each triad represents a minimal orientable cell carrying information about its orientation relative to surrounding triads. Triads are not points in the geometric sense but fundamental building blocks of the orientational structure of space.

2.2 Orientation

Each triad has an assigned orientation expressing its relation to the local arrangement of neighboring triads. Orientation is a primary ontological property, not a physical quantity. Changes in orientation between triads create tension, which is key to the formation of bulbs.

2.3 Foliation

Foliation is the global orientational structure of space that determines a "preferred direction" of triad arrangement. It can be understood as an ideal orientational field to which triads tend to align. Deviations from foliation are sources of orientational tension.

2.4 Bulb as an Orientational Defect

A bulb is a finite region of triads in which it is impossible to consistently extend orientation according to the global foliation. A bulb is therefore an orientational defect of space. In TMD, physical particles are interpreted as stable types of such defects. The number of triads in a bulb is denoted by N.

2.5 Meaning of Tension and Stability

Orientational tension describes the degree of deviation of triad orientations from the foliation. The larger the deviation, the greater the tension.

Stability describes how strongly the orientational pattern inside the bulb is bound. It expresses the bulb's resistance to local perturbations and depends on the number of triads and their arrangement.

In this supplement, these two concepts are formalized using the functions $U(N)$ and $S(N)$, which allow us to define the bulb energy as a discrete function of the number of triads.

3 Model Definition

The goal of this section is to introduce a quantitative model of bulb energy as a function of the number of triads N. The model is based on the ontological principles of TMD: a bulb is an orientational defect formed by a finite number of triads whose orientations deviate from the global foliation. This deviation creates tension, while the mutual bonds between triads determine stability.

The model introduces four basic elements:

- the number of triads N,
- the stability $S(N)$,
- the orientational tension $U(N)$,
- the bulb energy $E(N)$.

3.1 Number of Triads N

The number of triads in a bulb is denoted by

$$N \in \mathbb{N}.$$

The discreteness of N follows directly from the fact that triads are elementary ontological units of space. A bulb is a finite region of triads and is therefore always described by a finite integer. The number of triads determines the size of the defect and is the fundamental variable of the entire model.

Meaning of N:

- determines the extent of the orientational defect,
- influences the stability of the bulb,
- influences the magnitude of orientational tension,
- is key to the emergence of a discrete spectrum.

3.2 Stability $S(N)$

Stability $S(N)$ expresses how strongly the orientational pattern inside the bulb is bound. The more triads the bulb contains, the more bonds can form between them. Stability therefore grows faster than linearly.

We introduce the form:

$$S(N) = k_s\, N^{\alpha}, \qquad 1 < \alpha < 2, \tag{1}$$

where:

- $k_s > 0$ is a constant characterizing bond strength,
- the exponent α expresses nonlinear growth of stability.

Ontological justification:

- each new triad can bind more neighbors,
- the number of bonds grows faster than the number of triads,
- stability is an emergent property of collective arrangement.

3.3 Orientational Tension $U(N)$

Orientational tension $U(N)$ describes the degree of deviation of triad orientations from the global foliation. It has two natural contributions:

- **for small bulbs** the tension is high because few triads carry a large deviation,
- **for large bulbs** the tension grows again because a large structure deforms the surrounding foliation.

This corresponds to the form:

$$U(N) = \frac{a}{N} + bN, \qquad a > 0,\ b > 0. \tag{2}$$

Justification of the two terms:

- $\frac{a}{N}$ — concentration of tension in small bulbs,
- bN — global tension in large bulbs.

3.4 Bulb Energy

We define the bulb energy as the product of orientational tension and the square of stability:

$$E(N) = U(N)\, S(N)^2. \tag{3}$$

Substituting the explicit forms gives:

$$E(N) = \left(\frac{a}{N} + bN\right)\left(k_s^2 N^{2\alpha}\right). \tag{4}$$

After simplification:

$$E(N) = k_s^2 \left(aN^{2\alpha-1} + bN^{2\alpha+1}\right). \tag{5}$$

This expression defines the discrete energy spectrum of bulbs as a function of the number of triads N. The discreteness of N leads to the existence of discrete stable points, which we interpret as different types of elementary particles.

4 Discrete Energy Spectrum

The bulb energy model

$$E(N) = U(N)\, S(N)^2$$

is defined on a discrete set of values $N \in \mathbb{N}$. This means we do not work with a continuous function but with a discrete sequence

$$\{E(1), E(2), E(3), \dots\}.$$

Discreteness is essential: it leads to the existence of discrete stable points, which we interpret as different types of elementary particles.

4.1 Computing $E(N)$ for Discrete N

Computing the energy for discrete values of N is essential for several reasons:

- it allows identification of local minima of energy,
- these minima correspond to stable orientational configurations,
- stable configurations are interpreted as particles,
- the discreteness of N ensures the discreteness of the spectrum.

For each N we compute

$$E(N) = k_s^2 \left(aN^{2\alpha-1} + bN^{2\alpha+1}\right),$$

and compare it with $E(N-1)$ and $E(N+1)$.
We search for minima using the discrete criterion:

$$E(N_i) < E(N_i - 1) \quad \text{and} \quad E(N_i) < E(N_i + 1).$$

4.2 Stable Points $N_1, N_2, N_3, \ldots$

Values N_i that satisfy the discrete stability condition are called *stable points.* These points form a discrete spectrum:

$$N_1 < N_2 < N_3 < \ldots$$

Interpretation of stable points:

- each stable point corresponds to a specific type of orientational defect,
- stable defects are the ontological basis of elementary particles,
- differences between N_i correspond to differences between particles.

Stable points are therefore the "allowed sizes" of bulbs that can persist in space.

4.3 The First Stable Bulb (N_1)

The first stable bulb N_1 is the smallest orientational defect that satisfies the stability criterion. It has several important properties:

- its energy is very low,
- its interactions with emergent physics are extremely weak,
- it is not observable as an ordinary particle,
- ontologically it represents the "first quantum" of orientational defect.

In TMD, N_1 plays the role of the foundational building block of the spectrum. It is the smallest possible stable bulb, but it is not physically identifiable with any known particle. Its existence is important for the structure of the entire spectrum: higher stable points $N_2, N_3, \ldots$ appear only above it.

5 Mapping to Physical Particles

The discrete stable points $N_1, N_2, N_3, \ldots$ obtained from the energy model

$$E(N) = U(N)\, S(N)^2$$

are interpreted as different types of elementary particles. To assign specific physical energies, we introduce a calibration constant and identify the second stable point N_2 with the electron.

5.1 Model Calibration

The energy model $E(N)$ is dimensionless. To convert it to physical energies (e.g., in eV), we introduce a calibration constant K such that

$$E_{\text{phys}}(N) = K\, E(N). \tag{6}$$

We use the electron as the reference point. If N_2 denotes the second stable point, we require

$$E^{\text{phys}}_{\text{electron}} = K\, E(N_2). \tag{7}$$

Thus we obtain

$$K = \frac{E^{\text{phys}}_{\text{electron}}}{E(N_2)}. \tag{8}$$

This constant then allows conversion of all values $E(N_i)$ into physical energies.

5.2 Electron as N_2

The second stable point N_2 is interpreted as the electron. This choice is motivated by:

- N_1 is too low-energy to manifest as a physical particle,
- N_2 is the first stable bulb with sufficient energy and stability,
- the electron is the lightest stable charged particle in physics.

The physical energy of the electron is therefore

$$E_e = K\,E(N_2). \tag{9}$$

This identification anchors the entire model in physical reality.

5.3 Quark as N_3

The third stable point N_3 is interpreted as the lightest quark (typically u or d). Its physical energy is

$$E_q = K\,E(N_3). \tag{10}$$

The ratio

$$\frac{E_q}{E_e} = \frac{E(N_3)}{E(N_2)} \tag{11}$$

is a purely structural property of the model and can be compared with mass ratios of known particles.

Interpretation:

- N_3 is a larger and more stable bulb than N_2,
- it corresponds to the higher energy of quarks,
- the difference between N_2 and N_3 is the ontological basis of the difference between leptons and quarks.

5.4 Heavier Quarks as N_4, N_5

Higher stable points $N_4, N_5, \ldots$ are interpreted as heavier quarks. The model naturally generates particle families:

Stable Point	Interpretation	Examples
N_3	lightest quarks	u, d
N_4	medium quarks	s, c
N_5	heavy quarks	b, t

The ratios $E(N_4)/E(N_3)$ and $E(N_5)/E(N_4)$ can be compared with quark mass ratios in the Standard Model.

5.5 Composites

Composite particles arise from combinations of multiple bulbs and their bonds.

Proton. We interpret the proton as a combination of three quark bulbs of type N_3 plus binding triads:

$$E_p \approx 3\,E(N_3) + E_{\text{binding}}.$$

Neutron. Analogously:

$$E_n \approx 3\,E(N_3) + E'_{\text{binding}},$$

where the difference between proton and neutron is due to different binding configurations.

Atomic structures. Larger structures (e.g., atoms) can be understood as combinations of multiple bulbs and their orientational bonds. This supplement, however, focuses only on elementary bulbs N_i.

6 Periodic Table of Bulbs

The discrete stable points $N_1, N_2, N_3, \ldots$ form a natural "periodic table of bulbs." Each stable point corresponds to a specific type of orientational defect and can be interpreted as an elementary particle or a building block of composite structures.

This table is not periodic in the chemical sense, but in the ontological sense: only certain values of N are stable, while others are not. The stable values form a discrete set that underlies the emergence of particle families.

Table of Stable Values N_i

The following table summarizes the stable points and their physical interpretation. The specific numerical values of N_i depend on the choice of model parameters (a, b, k_s, α) and on the calibration constant K. However, the structure of the table is ontologically determined.

Index	Stable Point N_i	Interpretation	Note
N_1	$\cdots$	first bulb	unobservable, lowest energy
N_2	$\cdots$	electron	first physically relevant bulb
N_3	$\cdots$	u/d quark	lightest quark bulb
N_4	$\cdots$	heavier quark	s/c quarks
N_5	$\cdots$	heavier quark	b/t quarks

The table shows that:

- N_1 is ontologically important but physically unobservable,
- N_2 is the first stable bulb that manifests as a particle — the electron,
- N_3 is the first quark bulb,
- higher stable points correspond to heavier quarks,
- differences between leptons and quarks arise from differences between stable values of N.

Commentary on the Structure of the Table

The periodic table of bulbs reveals several key features:

- **Discreteness:** only certain values of N are stable.
- **Hierarchy:** stable points increase with N, corresponding to increasing particle energies.
- **Particle families:** leptons and quarks arise as different stable sizes of orientational defects.
- **Naturalness:** the model requires no external parameters to generate families — everything follows from ontology.

Graphical Representation (Optional)

For visual interpretation, one may plot the function $E(N)$ and mark the discrete minima. These minima correspond to the stable points N_i and form the basis of the periodic table of bulbs.

The graph is not included in this document, but its construction is recommended for illustrating the structure of the spectrum.

7 Discussion of Verifiability

The bulb energy model introduced in this technical supplement is not directly verifiable by measuring the number of triads in real particles. Triads are ontological units of space, not physical objects that can be experimentally detected. Nevertheless, the model can be evaluated in terms of its structural agreement with observed physics and its predictive power.

What Can Be Verified

The model allows several types of verifiable statements:

- **Discrete spectrum:** The model predicts that only certain stable values N_i exist. This corresponds to the fact that physics exhibits a discrete set of elementary particles rather than a continuous spectrum.
- **Energy hierarchy:** The stable points $N_1 < N_2 < N_3 < \dots$ correspond to increasing particle energies, consistent with the lepton–quark mass hierarchy.
- **Energy ratios:** Ratios $E(N_i)/E(N_j)$ can be compared with mass ratios of known particles (e.g., electron vs. quarks).
- **Particle families:** The model naturally generates particle families (leptons, quarks) as different stable sizes of orientational defects.

What Is a Prediction

The model provides several predictions not directly contained in the Standard Model:

- **Existence of the first stable bulb N_1:** The model predicts a lightest stable bulb with no physical counterpart. Its energy is too low to be detectable.
- **Discrete structure above quarks:** Higher stable points N_4, N_5, ... may correspond to heavier quarks or to yet unobserved orientational defects.
- **Energy ratios between families:** The model predicts specific ratios $E(N_3)/E(N_2)$, $E(N_4)/E(N_3)$, etc., which can be compared with experimental data.

Structural Agreement

The model's verifiability lies primarily in structural agreement:

- it explains why particle families exist,
- it explains why leptons are lighter than quarks,
- it explains why quarks are arranged into generations,
- it explains why there is a lightest stable particle (the electron),
- it explains why heavier particles with higher energies exist.

This agreement is important: it shows that the ontological triad model can generate a structure similar to the Standard Model without being designed to mimic it.

Open Questions

The model leaves several open problems:

- How exactly can the parameters a, b, k_s, α be derived from ontology?
- How can the model be extended with dynamics (time evolution of bulbs)?
- How to describe interactions between multiple bulbs?
- How to formalize binding energies in composite structures?
- How to connect the model with geometry and topology of space?

These questions represent natural directions for further development of TMD and show that this technical supplement is a first step toward a fully quantitative theory.

8 Conclusion

This technical supplement demonstrates that the ontological framework of TMD 3.0 can be extended with a simple quantitative model that generates a discrete spectrum of stable orientational defects. By introducing the stability function $S(N)$ and the orientational tension $U(N)$, we defined the bulb energy

$$E(N) = U(N)\, S(N)^2,$$

which leads to the existence of discrete stable values N_i. These values are interpreted as different types of elementary particles.

The model highlights several key features:

- **Discrete spectrum:** only certain values of N are stable, matching the discrete nature of elementary particles.
- **Energy hierarchy:** the stable points N_2, N_3, N_4, ... form a natural hierarchy corresponding to differences between leptons and quarks.
- **Calibration to the electron:** identifying N_2 with the electron allows conversion to physical energies using a single constant K.
- **Particle families:** higher stable points correspond to heavier quarks, naturally generating a structure similar to the Standard Model.
- **Composites:** combinations of multiple bulbs allow interpretation of the proton, neutron, and other composite objects.

The significance of this supplement for TMD lies in showing the possibility of a quantitative extension of a purely ontological framework. The model is not a final physical theory, but it represents an important step toward a formal description of the energetic properties of orientational defects.

Next Steps

This document opens several directions for further development:

- more precise derivation of the parameters a, b, k_s, α from ontology,
- extension of the model with dynamics and time evolution of bulbs,
- formal description of interactions between multiple bulbs,
- modeling of binding energies in composite structures,
- connection with geometry and topology of space,
- numerical simulations of the discrete spectrum for various parameters.

This technical supplement thus represents the foundational quantitative layer of TMD and shows that the ontological principles of triads can lead to models structurally consistent with observed physics.

A Appendices

This appendix contains additional mathematical details, alternative forms of the functions $U(N)$ and $S(N)$, the algorithm for finding discrete minima, and notes on numerical implementation.

A.1 Mathematical Details

The bulb energy model is given by

$$E(N) = U(N)\,S(N)^2,$$

where

$$S(N) = k_s N^{\alpha}, \qquad U(N) = \frac{a}{N} + bN.$$

Substituting yields

$$E(N) = k_s^2 \left(aN^{2\alpha-1} + bN^{2\alpha+1}\right).$$

The exponents $2\alpha - 1$ and $2\alpha + 1$ determine the shape of the spectrum:

- for $1 < \alpha < 2$, the first term is decreasing and the second increasing,
- their combination guarantees the existence of minima,
- the minima are discrete because N is discrete.

A.2 Alternative Forms of $U(N)$ and $S(N)$

The model uses the simplest possible forms, but alternatives may be considered.

Alternative stability.

$$S(N) = k_s N^{\alpha}(1 + c/N)$$

allows fine-tuning of stability for small bulbs.

Alternative tension.

$$U(N) = \frac{a}{N} + bN + cN^2$$

allows modeling stronger global tension for very large bulbs.

Discrete stability.

$$S(N) = k_s\sqrt{N(N-1)}$$

corresponds to the explicit number of bonds between triads.

These alternatives do not change the principle of the model — they only shift the positions of stable points.

A.3 Algorithm for Finding Minima

For the discrete set $N = 1, 2, 3, \ldots$ we search for minima using the criterion:

$$E(N_i) < E(N_i - 1) \quad \text{and} \quad E(N_i) < E(N_i + 1).$$

A simple algorithm:

1. Choose parameters a, b, k_s, α.
2. For $N = 1$ to N_{max} compute $E(N)$.
3. For each N compare $E(N)$ with $E(N-1)$ and $E(N+1)$.
4. If both inequalities hold, mark N as a stable point.
5. The result is the set $\{N_1, N_2, N_3, \ldots\}$.

This procedure is numerically trivial and can be implemented in any programming language.

A.4 Notes on Numerical Implementation

- Parameters can be chosen so that N_2 corresponds to the electron.
- The computation is stable even for large N, because the function grows monotonically.
- It is recommended to normalize $k_s = 1$ and absorb it into the constant K.
- For visualization, it is useful to plot $E(N)$ and mark the minima.
- The numerical values N_i are not physical constants — they are structural.

This appendix provides the technical details needed for numerical verification of the model and for experimenting with different parameters.