# Topological Origin of Mass Hierarchy in Unified Biquaternion Theory

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**Abstract**

We propose a novel explanation for the mass hierarchy of elementary particles based on the topological modes of the unified biquaternionic field $\Theta(q, \tau)$. This framework generalizes the concept of Hopfions to higher winding numbers, offering a natural mechanism for the existence of three generations of leptons and their sharply differing rest masses. Each particle generation corresponds to a stable topological mode indexed by its Hopf charge $n$, and its mass is derived from a universal topological energy function $S(n)$.

## 1 Introduction

The Standard Model of particle physics classifies leptons into three generations—electron, muon, and tau—with increasing rest masses. However, it does not provide a fundamental explanation for these mass ratios. We hypothesize that these generations correspond to quantized topological excitations of the $\Theta$ field, each with a distinct Hopf charge $n$.

## 2 Topological Energy Function $S(n)$

The topological energy function $S(n)$ approximates the rest energy of each stable excitation:

$$S(n) = an^p + b,$$

where $n \in \mathbb{Z}_+$ is the Hopf index, and $a$, $p$, $b$ are constants fitted to experimental mass values.

### 2.1 Fitting to Lepton Masses

Let $m_e$, $m_\mu$, and $m_\tau$ be the rest masses of electron, muon, and tau, respectively. We assign:

$$S(1) = m_e, \quad S(2) = m_\mu, \quad S(3) = m_\tau.$$

Assuming $p = \frac{3}{2}$ and $b = 0$, solve for $a$:

$$a = \frac{m_\mu}{2^{3/2}} = \frac{m_\tau}{3^{3/2}}.$$

Using experimental values:

$$\begin{aligned} m_e &= 0.511 \text{ MeV}, \\ m_\mu &= 105.66 \text{ MeV}, \\ m_\tau &= 1776.86 \text{ MeV}, \end{aligned}$$

we get:

$$a_\mu = \frac{105.66}{2.828} \approx 37.37, \quad a_\tau = \frac{1776.86}{5.196} \approx 341.96.$$

This suggests that a single power law may not fit all three values unless we include a correction term or consider different scaling regimes.

# 3 Discussion

We propose that each particle generation corresponds to a distinct topological structure. The sharp increase in mass between generations suggests a nonlinear scaling in topological complexity or self-interaction energy.

Possible future refinements:

- Introduce log-corrections to $S(n)$,
- Use exact Hopfion energy functionals,
- Include interaction with curvature or field tension.

# 4 Conclusion

The mass hierarchy problem may be geometrically and topologically encoded in the $\Theta$ field structure. The hypothesis is testable via the relationship between topological energy scaling and observed mass ratios, offering a unifying explanation within UBT.

# Author's Note

This work was developed solely by Ing. David Jaroš. Large language models (ChatGPT-4o by OpenAI and Gemini 2.5 Pro by Google) were used strictly as assistive tools for calculations, LaTeX formatting, and critical review. All core ideas, equations, theoretical constructs and conclusions are the intellectual work of the author.