A Cube in the Land of Quanta: How Simple Geometry Tamed the Greatest Mystery of Charge

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p-Gluon Model: Z1, Sp, G0, ZKP

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Abstract

This work presents a radically simplified yet remarkably fertile explanation of the origin of electric charge, achieved through the application of the **sonar method [4]** in theoretical physics. This method consists of adopting a minimal set of geometric assumptions and systematically "listening" to their logical consequences rather than constructing elaborate mathematical formalisms.

Assuming only: (1) the existence of p-gluons as quanta of spacetime with polarization $Z1$, (2) the directional code Sp, and (3) the Möbius strip G_0, sonar consistently leads to an emergent definition of charge

$$Q = \text{Transfer}(G_0 \circ Sp(Z1_{\text{ordered}}))$$

and to the fundamental discovery of a **critical energy threshold** $E_{\text{crit}} \approx m_e c^2$.

This threshold, arising solely from the logic of the model, becomes a universal filter: everything below it must be neutral, everything above it is charged. In this way, **sonar explains in a single step**:

- **the impossibility of charged particles lighter than the electron**,
- **the enforced neutrality of all neutrinos**,
- **the discrete character of charge** as a phase transition.

The simplicity of the model (school supplies as physical analogues) contrasts with the depth and coherence of the explanations, demonstrating the power of the sonar method in uncovering fundamental principles of the construction of reality.

Contents

1 Introduction

The goal of this work is to formally organize the model in which electric charge is emergent topological information carried to the particle boundary (ZKP) by the structure of p-gluons. The model distinguishes three fundamental components:

1. the local helical polarization of p-gluons (Z1),
2. the orientation of information transport (Sp1/Sp2),
3. the topological transfer mechanism (Möbius strip G0).

Charge appears only when these three elements operate simultaneously and when the ZKP exceeds the energy threshold E_{crit} stabilizing the ordering of Z1. The result: a natural explanation of charge quantization and neutrino neutrality.

2 Glossary of Concepts and Assumptions

p-gluon (pG) [6] A quantum of local spacetime structure possessing **two opposite faces**, where:

$$Z1(+) \quad \text{lies on one face,} \qquad Z1(-) \quad \text{lies on the opposite face.}$$

This pair forms a **fundamental directional dipole**, whose degree of ordering inside the particle determines the ability of the structure to transmit charge information.

ZKP / RKP [1] Compact / expanded vacuum configuration.

Z1 [6] Local (helical) polarization of the p-gluon: $Z1(+)$ or $Z1(-)$.

Sp [8] Global orientation of transport (Sp1/Sp2).

G0 Möbius strip transferring information to boundary K.

K Boundary of the compact configuration — the interface of observable quantities.

E_{crit} Critical energy required to order Z1.

2.1 1. Model Glossary [3]

- **dK** — the inner wheel, the "vortex engine." Its motion determines:
  - the particle's internal cycle,
  - the orientation of the world (o^+ or o^-),
  - the way geometry flows through the strip G.
- **G** — the gear-belt, a Möbius strip. It connects dK to the boundary. It imposes the spinor ratio: two rotations of dK → one rotation of K. G0 and G8 are coupling variants.
- **K** — the small wheels on the particle boundary — the "screen" of visible properties:
  - charge (Sp1/Sp2) is encoded here,
  - spin ST manifests here,
  - geometry from dK arrives here through G.

- **ST** — the arrow on the belt (boundary spin). After two full rotations of dK, it returns to the same configuration. This is the source of the 4π spinor property.
- **Sp** — the spin variant of the boundary. It is information, not motion:

$$\text{Sp1} \to (-)$$
$$\text{Sp2} \to (+)$$

- **O** — the world axis — the global orientation of RKP(+). The particle "reads" this axis like a compass reads a magnetic field.

3 Minimalism of the Model: From Complex 3D+4D Topology to Simple Boundary Encoding

3.1 The Problem of Representing Spinor Topology

The geometry of the complete charge-generation mechanism in the p-gluon model involves:

- a real object (ZKP) rotating in 3D space,
- its rotational axis oriented in 4D spacetime,
- the Möbius strip (G_0) transmitting information in an irreducibly topological way,
- the dK cycle as a spinor object lacking a classical axis of rotation.

This combination — 3D geometry, 4D orientation, and Möbius topological coupling — is **irreducibly complex**. Mechanical visualization attempts lead to intuitive errors, because neither spinors nor the Möbius strip have classical analogues.

3.2 Fundamental Assumption: Boundary Encoding

Instead of trying to represent unrepresentable motions in 4D spacetime, the model adopts a fundamental assumption of simple, unambiguous encoding of information on the ZKP boundary:

$\boxed{\text{Sp1: Z1 cubes arranged with “6 forward”}}$ $\boxed{\text{Sp2: Z1 cubes arranged with “1 forward”}}$

where:

- "6" encodes polarization $Z1(-)$ (negative),
- "1" encodes polarization $Z1(+)$ (positive),
- "forward" denotes the global direction of information transfer through G_0 to boundary K.

3.3 Why This Assumption Is Necessary and Sufficient?

1. **It replaces unrepresentable dynamics**: no need to visualize a 4D axis, classical spin, or the Möbius 2:1 mapping.
2. **It preserves the entire content of the model**:
    - the "6/1 forward" encoding determines global orientation of the dK cycle,
    - the Sp1/Sp2 difference corresponds to opposite charge signs,
    - lack of Z1 ordering (as in neutrinos) gives $Q = 0$,

- the critical energy E_{crit} determines stability of ordering.

3. **It is consistent with quantum physics**:
   - spin-$\frac{1}{2}$ has no classical rotational interpretation,
   - the "spin axis" is a state vector, not a direction in space,
   - the 4π rotation property is topological,
   - $\mathrm{SU}(2) \to \mathrm{SO}(3)$ mapping governs the spinor–vector relationship.

4. **It enables construction of physical predictions** without loss of mathematical or topological coherence.

3.4 Consequences of the Adopted Approach

Advantages

- intuitive, visual model,
- unambiguous operational definitions of Sp1/Sp2,
- preservation of key physical features: charge quantization, neutrino neutrality, threshold energies,
- minimal assumptions — no mechanical artefacts.

Limitations

- the model does not describe literal rotating mechanics,
- it operates at an emergent level (boundary information rather than p-gluon dynamics),
- full formalization requires a dynamical model of the p-gluon network.

3.5 Conclusion: Not a Compromise but the Correct Formulation

Adopting boundary encoding Sp1/Sp2 is the correct formulation of the model because:

1. it preserves the mathematical content of spinors and Möbius topology,
2. it allows charge to emerge from Z1 ordering controlled by E_{crit},
3. it enables construction of testable predictions,
4. it keeps the model intuitive, unambiguous, and operational.

The p-gluon model abandons literal mechanics in favor of describing emergent properties through simple encoding of geometric information. This resolves the representation problem and highlights the fundamental nature of charge as a property arising from ordered information on the boundary of a compact spacetime configuration.

4 The Electron and Positron Model – Geometric Description

The purpose of this section is to introduce the reader to the mechanism by which the electron operates: the sleeve, the elastic strip, the boundary wheels K, the Möbius strip G, the dK cycle, and the world axis O. This is the basic "engine of the particle."

5 Formal Definition of Charge

$$Q = \mathrm{Transfer}\big(G0 \circ Sp(Z1_{\mathrm{ordered}})\big). \tag{1}$$

Interpretation:

- $Z1_{\mathrm{ordered}}$ — ordered p-gluon threads,
- $Sp(\cdot)$ — assignment of transport direction,
- $G0$ — topological mapping onto boundary K,
- Transfer — emergence of the electromagnetic field.

Charge does not exist for $Z1_{\mathrm{ordered}} = 0$.

5.1 Symbolic Interpretation in Mathematical Language

$$\mathrm{Sp1} \longleftrightarrow |\psi_1\rangle \in \mathbb{C}^2 \qquad \text{(first spinor component, boundary information direction)} \tag{2}$$

$$\mathrm{Sp2} \longleftrightarrow |\psi_2\rangle \in \mathbb{C}^2 \qquad \text{(second spinor component, boundary information direction)} \tag{3}$$

$$\mathrm{dK} \longleftrightarrow \sigma_z \qquad \text{(generator of local phase change of } dK \text{ in SU(2))} \tag{4}$$

$$\mathrm{K} \longleftrightarrow R(\theta) = \exp\Big(-\tfrac{i\theta}{2}\,\vec{n}\cdot\vec{\sigma}\Big) \qquad \text{(full SU(2) rotation operator, boundary image of the cycle)} \tag{5}$$

where $\vec{\sigma} = (\sigma_x, \sigma_y, \sigma_z)$ are Pauli matrices, and $|\psi\rangle$ denotes a two-component spinor describing the boundary configuration.

6 Mechanism of Charge Formation

1. The ZKP undergoes excitation and compression.
2. For $E_{\mathrm{ZKP}} \geq E_{\mathrm{crit}}$, Z1 becomes ordered.
3. Sp1/Sp2 set the direction of information transport.
4. G0 transfers the ordering to boundary K.
5. An EM field and charge $Q = \pm 1$ are produced.

7 Definition of Charge in the Pencil Case Model

7.1 Introduction

Charge is an emergent geometric phenomenon resulting from:

1. Z1 polarization,
2. orientation of the Möbius strip $G0$,
3. the directional code Sp1/Sp2.

The particle boundary K does not create charge — it merely receives geometric information.

7.2 Role of Z1 Polarization

$$Z1_{\text{ordered}} = \{Z1_i \text{ coaxial and ordered}\}.$$

In the RKP(+) state, Z1 polarizations are chaotic; ordering requires exceeding E_{crit}.

7.3 Role of Orientation Sp

Sp1/Sp2:

- determine transport direction,
- define world orientation I/II,
- co-determine chirality.

7.4 Role of the Möbius Strip

G0:

- enforces spinor behavior (4π),
- connects dK to boundary K,
- transfers topological information.

It must be emphasized that neither the internal cycle dK nor the local Z1 polarizations are directly coupled. Only the topological coupling implemented by the Möbius strip G_0 binds these two levels of structure, producing coherent boundary information capable of becoming charge.

7.5 Formal Definition

$$Q = \text{Transfer}(G0 \circ Sp(Z1_{\text{ordered}})).$$

7.6 When Does Charge Not Form?

$$Z1_{\text{chaotic}} \;\Rightarrow\; Z1_{\text{ordered}} = 0 \;\Rightarrow\; Q = 0.$$

The neutrino is an example of a particle with full Sp, $G0$, K structure operating below the critical energy threshold E_{crit}, and therefore it does not generate charge.

Metaphor: Conveyor Belt and Dice

Imagine the mechanism of transferring Z1 polarization as a conveyor belt on which dice (p-gluons) move:

- At energies **well below** E_{crit}, dice lie randomly: orientations are arbitrary. Mathematically: $Z1_{\text{chaotic}} \to Z1_{\text{ordered}} = 0$.
- As energy **increases** but remains below E_{crit}, a statistical bias appears, aligned with direction of motion. Still insufficient for structured information that G_0 could transfer.
- At energies **equal or above** E_{crit}, all dice orient with the **6 facing forward** (full $Z1(-)$ polarization). G_0 performs ordered transfer and charge forms.
- Switching $Sp1 \to Sp2$ reverses interpretation: forward-facing becomes **1** (corresponding to $Z1(+)$).

This metaphor captures the logic of the model:

$$Q = 0 \quad \text{when} \quad E < E_{\text{crit}}, \qquad Q \neq 0 \quad \text{when} \quad E \geq E_{\text{crit}}.$$

8 Critical Energy of Charge

8.1 Definition

$$E_{\text{crit}} = \min\{E_{\text{ZKP}} \mid Z1_{\text{ordered}} \neq 0\}. \tag{6}$$

8.2 Condition for Charge Formation

$$E_{\text{ZKP}} \geq E_{\text{crit}} \Rightarrow Q \neq 0,$$
$$E_{\text{ZKP}} < E_{\text{crit}} \Rightarrow Q = 0.$$

8.3 Interpretation

- charge quantization,
- minimum mass of a charged particle,
- explanation of neutrino neutrality.

9 The Neutrino as a Below-Threshold Particle

9.1 Neutrino Properties

- extremely low mass,
- chaotic Z1,
- full $G0$ and Sp structure,
- absence of Z1 ordering $\Rightarrow Q = 0$.

9.2 Mechanism

$$Z1_{\text{chaotic}} \xrightarrow{Sp} G0 \to K,$$
$$\text{Transfer}(0) = 0.$$

10 Charge Quantization as a Phase Transition

State	$Z1_{\text{ordered}}$	Q
$E < E_{\text{crit}}$	0	0
$E \geq E_{\text{crit}}$	$\neq 0$	± 1

No intermediate states.

$$Q \in \{-1, 0, +1\}.$$

11 Consequences of the Model

- minimum mass of a charged particle $\sim m_e$,
- absence of light charged particles,
- natural neutrality of neutrinos,
- dependence of the EM field on ZKP geometry.

12 Conclusions

$$\boxed{\text{Charge is emergent geometric information: } Q = \mathrm{Transfer}(G0 \circ Sp(Z1_{\mathrm{ordered}})).}$$

A key element is the energy threshold E_{crit}.

13 Empirical Estimate of the Critical Threshold for Charge Formation

13.1 Motivation

The p-gluon model predicts a minimum energy (or ZKP density) below which ordering of local $Z1$ polarizations cannot occur, and therefore electric charge cannot form. This section presents an empirical estimate of this energy based on known experimental data on masses and charges of elementary particles.

13.2 Basic Empirical Assumption

We adopt two observational facts:

1. the lightest charged particle in the Universe is the electron,
2. there is no observed particle with mass $m < m_e$ that carries charge $Q \neq 0$.

This means that in nature there is *no* particle configuration capable of carrying electric charge below the energy associated with electron mass. Thus, the electron defines the physical threshold for ordering of local Z1 threads.

13.3 Empirical Definition

The critical energy for charge formation E_{crit} therefore takes the value:

$$E_{\mathrm{crit}} \approx m_e c^2 = 0.51099895 \text{ MeV}.$$

Approximately:

$$\boxed{E_{\mathrm{crit}} \approx 0.511 \text{ MeV}}.$$

13.4 Consequence: the Neutrino Neutrality Threshold

If the mass of a particle satisfies $m < m_e$, then its structural energy is smaller than E_{crit}, which means:

$$E_{\mathrm{ZKP}} < E_{\mathrm{crit}} \quad \Longrightarrow \quad Z1_{\mathrm{ordered}} = 0 \quad \Longrightarrow \quad Q = 0.$$

According to experimental data:

$$m_{\nu_e},\ m_{\nu_\mu},\ m_{\nu_\tau} \ll 1 \text{ eV}/c^2,$$

therefore all neutrinos lie far below the threshold E_{crit} and *must be neutral.*

13.5 Universality of the Threshold

Combined with other empirical data:

- every lepton heavier than the electron (muon, tau) is charged,
- every charged hadron has mass far greater than m_e,
- no particle with mass $m < m_e$ carries charge.

All observational data align with one principle:

$$\boxed{\text{Electric charge is possible only when } E_{\mathrm{ZKP}} \geq E_{\mathrm{crit}}.}$$

13.6 Interpretation in the p-Gluon Model

The boundary E_{crit} represents the minimum energy needed for:

1. stabilizing the geometry of the Compact Vacuum Configuration (ZKP),
2. enforcing coaxial ordering of $Z1$ on its surface,
3. enabling transfer of Z1 information through Sp and G_0 to boundary K.

Below this energy:

- the ZKP remains too weakly compressed,
- p-gluons oscillate chaotically,
- Z1 ordering cannot occur,
- the mechanism $Sp \to G_0 \to K$ transmits only "noise."

Thus:

$$Q = 0 \quad \text{(neutral particles below threshold)}.$$

13.7 Physical Interpretation

From the standpoint of physical observations, the threshold E_{crit} defines the minimum energy a particle must possess to:

- maintain a nonzero charge,
- generate an electromagnetic field,
- participate in electromagnetic interactions in a stable manner.

All these effects are absent for particles below electron mass.

Significance of the Threshold E_{crit}

It is important to emphasize that:

$$E_{\text{crit}} = m_e c^2 \approx 0.511 \text{ MeV}$$

is not merely a convenient model assumption but an **empirical structural principle of particle physics**.

The lightest charged particle — the electron — establishes the observed boundary below which no particle in nature possesses charge:

$$m < m_e \quad \Longrightarrow \quad Q = 0.$$

Although well known from particle catalogs, this is rarely interpreted as a *fundamental threshold relation*. In the p-gluon model it acquires **central structural significance**: charge can arise only when the particle's energy exceeds the threshold needed to stabilize ordered Z1 polarization.

For the first time, the electron mass threshold is linked to the mechanism of charge generation as an emergent property.

14 Explanatory Power of the Model

This section summarizes the new explanatory mechanisms that emerge directly from the internal logic of the p-gluon model. The purpose is not to compare the model with existing physical theories, but to identify the phenomena that follow naturally from the geometric structure

$$Z1 \xrightarrow{Sp} G_0 \xrightarrow{\text{Transfer}} K.$$

The following results arise without any external assumptions.

14.1 Absence of Charged Particles Below the Electron Mass

Within the model, electric charge requires ordered $Z1$. This ordering is only possible when the structural energy satisfies:

$$E_{\text{ZKP}} \geq E_{\text{crit}}.$$

Since $E_{\text{crit}} \approx m_e c^2$, any configuration with $m < m_e$ necessarily satisfies:

$$Z1_{\text{ordered}} = 0 \quad \Rightarrow \quad Q = 0.$$

Thus, the model provides a geometric reason for the empirical fact that there exist no charged particles lighter than the electron.

14.2 Neutrino Neutrality

Neutrinos possess full Sp, G_0, and K structure, yet their extremely small mass implies:

$$E_{\text{ZKP}} \ll E_{\text{crit}}.$$

Consequently,

$$Z1_{\text{ordered}} = 0, \qquad Q = 0.$$

Neutrino neutrality emerges as a direct structural consequence rather than an imposed property.

14.3 Origin of the Charge Sign

The sign of charge follows from the direction of boundary information transport:

$$\text{Sp1} \Rightarrow Q = -1, \qquad \text{Sp2} \Rightarrow Q = +1.$$

The difference between electron and positron is encoded not in their internal structure but in the orientation of information flow through G_0.

14.4 Quantization of Charge

The boundary K can occupy only three states:

$$Q \in \{-1, 0, +1\}.$$

This results from the geometry of $Z1$ ordering and the topological mapping of G_0, leaving no possibility of intermediate fractional values.

Charge appears as a phase transition rather than as a continuous parameter.

14.5 Spinor Properties from Möbius Geometry

The Möbius strip G_0 enforces the spinor relation:

$$2 \text{ rotations of } dK \longrightarrow 1 \text{ rotation of } K,$$

which naturally yields the 4π structure characteristic of spin-$\frac{1}{2}$.

Thus, spinor behavior arises from geometry rather than algebraic postulates.

14.6 Structural Symmetry of the Electron and Positron

Electron and positron share:

- identical ZKP geometry,
- identical p-gluon ordering structure,
- identical dK and G_0 topology.

Their only difference lies in:

$$Sp1 \leftrightarrow Sp2,$$

which reverses the interpretation of the same ordered $Z1$ configuration.

14.7 Summary

The model provides unified geometric explanations of:

- absence of light charged particles,
- neutrality of neutrinos,
- sign of electric charge,
- quantization of charge,
- spinor properties,
- electron–positron symmetry.

These results emerge solely from the internal structure of the model and require no reference to external theoretical frameworks.

15 What the Model Explains vs. What Academic Physics Does Not

This section organizes the contrast between mechanisms that arise directly from the geometry of the p-gluon model and those features of modern physics that are correctly *described* by equations but lack a structural or causal explanation.

This is not a criticism of physics, but a clarification of the difference between:

describing a phenomenon with equations vs. explaining it with a mechanism.

15.1 Why is the electron the lightest charged particle?

Standard Model: Treats this as an empirical fact. The electron mass is an input parameter. Nothing in the Standard Model forbids the existence of a lighter charged particle. If a charged particle with mass $0.1\,m_e$ were discovered tomorrow, the SM would remain intact — one would simply add a new parameter.

p-Gluon Model: Provides a geometric explanation:

$$E_{\text{crit}} = m_e c^2.$$

Below this energy, ordering of $Z1$ cannot occur, and thus *charge cannot form.* This result arises from the structure of the model, not from adjusting equations.

15.2 Why are neutrinos neutral?

Standard Model: Neutrino neutrality is a fundamental assignment. There is no underlying mechanism that prevents neutrinos from being charged; they are simply defined as neutral.

p-Gluon Model: Neutrality follows from:

$$E_{\text{ZKP}} \ll E_{\text{crit}} \quad \Rightarrow \quad Z1_{\text{ordered}} = 0.$$

Neutrinos do not reach the structural threshold required for $Z1$ ordering. Neutrality is a *logical consequence* of the geometry.

15.3 Why does charge have two signs?

Standard Model: The sign of charge is a property assigned to fields — positive or negative. There is no structural mechanism explaining why the electron and positron have opposite signs.

p-Gluon Model: The sign is determined by the direction of information transport:

$$Sp1 \to Q = -1, \qquad Sp2 \to Q = +1.$$

The sign is not a metaphysical attribute but a consequence of how ordered $Z1$ passes through the Möbius strip G_0.

15.4 Why is charge quantized?

Standard Model: Charge quantization is imposed by the structure of the $U(1)$ gauge group. The fact that $Q \in \{-1, 0, +1\}$ is an algebraic rule, not a derived necessity. The SM does not explain why nature chose this structure.

p-Gluon Model: Quantization is a phase transition:

$$Z1_{\text{ordered}} = 0 \Rightarrow Q = 0, \qquad Z1_{\text{ordered}} \neq 0 \Rightarrow Q = \pm 1.$$

No intermediate states exist because the topological operator G_0 can only transfer a fully ordered state or its complete reversal.

15.5 Where does spinor behavior come from?

Standard Model: Spin-$\frac{1}{2}$ is built into the Hilbert space and Lorentz representation theory. The 4π rule has no geometric or mechanistic explanation — it is a property of algebraic representations.

p-Gluon Model: Spinor behavior emerges from Möbius geometry:

$$2 \text{ cycles of } dK \to 1 \text{ rotation of } K.$$

This provides a geometric origin for the 4π property.

15.6 Summary of Differences

Phenomenon	**Standard Model**	**p-Gluon Model**
Minimum mass of a charged particle	unexplained	emerges from E_{crit}
Neutrino neutrality	assigned property	consequence of $E_{\text{ZKP}} \ll E_{\text{crit}}$
Sign of charge	parameter choice	direction Sp1/Sp2
Charge quantization	$U(1)$ algebra	Z1 phase transition
Spinor behavior	representation theory	Möbius geometry

The p-gluon model therefore provides *mechanisms* where the Standard Model provides *equations*. Both approaches can coexist, but they serve different roles: one describes, the other explains.

DECLARATION OF COLLABORATION AND ACKNOWLEDGMENTS

Authorship of the Concept: 100% of the physical ideas, the p-gluon model, the definitions of Z1, Sp, G0, ZKP, and all theoretical predictions belong exclusively to the author (Arkadiusz Okupski).

Editorial Collaboration: In the creation of this document, linguistic assistance from the GPT model was used in the following areas:

- editing and proofreading,
- structuring the logical argument,
- formatting the LaTeX document,
- identifying semantic inconsistencies,
- suggesting improvements to clarity.

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