The bpdq Model:
Resolving Quark Generations and Preon Mass Fine-Tuning

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Abstract

The Standard Model perfectly describes the system of elementary particles and their interactions, yet it fails to explain why there are precisely three generations of quarks and leptons, and why quarks possess fractional electrical charges. Furthermore, it does not address gravity's fundamental mechanism in forming spacetime. This paper presents a novel structural model to shed light on these open questions. The model explores how a fundamental particle theory can be constructed from the simplest possible combination of a single chiral particle (b) and its antiparticle (q). Through geometric reflection, four elementary components emerge (b, p, d, q), whose purely topological shapes directly encode chirality and helicity. By introducing an invariant isospin (iI) and an invariant hypercharge (iY), electric charge (Q) is defined as an emergent property of specific substructures within states. The model demonstrates that simple combinatorial rules spontaneously generate structural quartets consisting of one lepton alongside three isomeric quark structures, whose statistical charges correspond exactly to the fractional charges of quarks. [1]

Crucially, the model resolves the classic mass paradox and fine-tuning problem of preon theories—where massive binding energies must artificially cancel bare energies—by introducing an intrinsic, algebraic subtraction mechanism within the relationship between the W, Z, and the electron. Through the structural combinations W+Z-W, W+Z-Z, and the complete subtraction W+Z-W-Z -> e, the dynamic mass generation of the weak bosons and the very low mass of the electron are derived directly from state definitions without free parameters. Within this framework, both mass and electric charge emerge as phenomena strictly bound to irregular helicity configurations, identifying the seemingly vanished binding energy as the structural energy equivalent of the electric charge. This mechanism mirrors the immense energy scales conceptually postulated in Majorana-like mass terms for right-handed states without charge. [6] Tthe Higgs boson is naturally identified not as a separate elementary particle, but as the massive, scalar excitation state of the fundamental vacuum (bpdq) showing an inherent structural preference for aligned, "regular" helicities that governs the mass generation and electrical charge of particles.

Finally, a potential connection to geometric gravitation theory is suggested, reminiscent of historical attempts to explain gravity as a structural residue between electric attraction and repulsion [4] Here pairs of photons of spin 2 interact via a double spinflip with neutrinos as the fundamental building blocks of all matter.

1. Introduction and Basic Assumptions

This model was created out of curiosity: what kind of structural assembly would result from only one particle and its antiparticle by combining them in the most straightforward manner using a reduced set of simple rules?

It is assumed that this basic particle, let us call it **b**, is of a chiral nature. Its antiparticle will be referred to as **q**, which is, by appearance and all its properties, the exact opposite of **b**. It is further assumed that both have an angular momentum or spin of 1/2, making them fermions. The letters **b** and **q** themselves geometrically represent spin and chirality.

For each of the two possible chiralities, the orientation of the angular momentum relative to chirality may result in two different energy levels. Since handedness is of fundamental importance in particle physics, it is suggested that helicity is an intrinsic property. While the duality of chirality is based on rotational symmetry, the duality of helicity is based on mirror symmetry. As mirror images, we define **p** to be the mirror image of **b**, and **d** to be the mirror image of **q**. This establishes four fundamental elementary components (EC, plural ECs):

- **Component b:** Chirality = 1, Helicity = 1, Spin = 1/2, Regularity = regular
- **Component p:** Chirality = 1, Helicity = -1, Spin = -1/2, Regularity = irregular
- **Component d:** Chirality = -1, Helicity = 1, Spin = 1/2, Regularity = irregular
- **Component q:** Chirality = -1, Helicity = -1, Spin = -1/2, Regularity = regular

Helicity as an intrinsic property is classified as regular or irregular relative to chirality. One may compare this relationship to that of a ship's propeller running either with or against its design for optimum propulsion: its performance characteristics are invariant to the frame of reference, unlike ordinary spin. In this table, momentum is assumed to be directed upward, meaning spin and helicity are parallel to each other.

Several elementary components may connect to form a single State.

2. Mathematical Formalism of a State

Combinatorial Rules

- Combinations of elementary components (EC) within a single state may contain each component to a maximum of 1 time (exclusion principle).
- The order of notation of the components within a state is irrelevant: xy = yx.
- Combinations of independent states are permitted (this leads to the quark structures discussed in later sections). Binding of states occurs through exchange of ECs.

- The structures of individual states correlate with neutrinos, vector bosons, and electrons, strongly suggesting a topological substructure that acts as the primary carrier of electric charge. Using these simple rules, assemblies of states form whose structures map precisely to the properties of all leptons and quarks in the Standard Model

For every state, the following mathematical rules apply, which were derived directly from the inspection of all possible states of connected elementary components:

1. **Invariant Isospin (iI):** Defined as an additive quantum number by the formula:
   iI = 1/2 * Sum of Chirality
2. **Invariant Hypercharge (iY):** Defined by the absolute values of the components spins:
   iY = abs(Spin of d + Spin of q) - abs(Spin of b + Spin of p)
3. **Electric Charge (Q):** In this model, the electric charge of any state is defined by the relation:
   Q = iI + iY

3. One-State Particles

The order of notation of the elementary components (EC) within a state is irrelevant (xy = yx). Flipping the spins of all components within a particle yields the identical particle with reversed spin.

A single state, representing the first generation of particles, allows exactly the following 9 fundamental configurations:

1. State **b**: iI = 1/2, iY = -1/2, Q = 0 -> Assignment: Neutrino
2. State **q**: iI = -1/2, iY = 1/2, Q = 0 -> Assignment: Antineutrino
3. State **bp** (or pb): iI = 1, iY = 0, Q = 1 -> Assignment: W+ Boson
4. State **qd** (or dq): iI = -1, iY = 0, Q = -1 -> Assignment: W- Boson
5. State **bq** (or pd): iI = 0, iY = 0, Q = 0 -> Assignment: Photon
6. State **bd** (or pq): iI = 0, iY = 0, Q = 0 -> Assignment: Z0 Boson
7. State **bqd** (or pqd): iI = -1/2, iY = -1/2, Q = -1 -> Assignment: Electron (L, R)
8. State **bpq** (or pbd): iI = 1/2, iY = 1/2, Q = 1 -> Assignment: Positron (R, L)
9. State **bpdq**: iI = 0, iY = 0, Q = 0 -> Assignment: Vacuum State

Explanations
flipping of spin is accomplished by exchanges b<->p or d<->q

Flipping of all spins of a particle resuls in the same particle having changed direction or being viewed in a mirror frame of reference

The ECs d and p are not listed here since left-handed antineutrino d and right-handed neutrino p are of irregular helicity and do not exist as free particles.

These assignments were initially made intuitively based on the observed relationships between neutrinos, electrons, W, and Z° bosons. The Z° boson decays into a neutrino and an antineutrino and is obviously neutral due to its composition. The second neutral boson assumes the role of the photon.

The decay relation W+ -> electron + antineutrino is formally equivalent to: W+ + neutrino = electron. Therefore, electric charge is assigned to a state containing bp or qd as +1 or -1. The mechanism of how a W boson can emerge from two neutrinos is explained under the section on binding mechanisms.

Example Calculation for the Electron (State bqd):

- iI(bqd) = iI(b) + iI(q) + iI(d) = 1/2 - 1/2 - 1/2 = -1/2
- iY(bqd) = abs(Spin of q + Spin of d) - abs(Spin of b) = abs(-1/2 + 1/2) - abs(1/2) = 0 - 1/2 = -1/2
- Q = iI + iY = -1/2 + (-1/2) = -1

4. Binding Mechanisms and the Solution to the Mass Paradox

4.1 Boson Exchange via the Polarized Vacuum

All interactions between particles occur with the active participation of the polarizable vacuum and the exchange of its components. Interactions and forces are formulated as direct interactions with the physical vacuum state, defined as "bpdq".

- **Binding of the W+ Boson (bp) via Z° Exchange:**
  The state bp polarizes the vacuum bpdq according to its own spin polarity:
  (bp) + Vacuum(bpdq) -> (b...p) + Z°(pq… Z°(bd)
  The algebraic rearrangement yields:
  (b + pq -> p + bq) and (p + bd -> b + pd) -> (pb) + Vacuum(bqpd)
  The vacuum returns to its initial state, while b and p have exchanged their positions. This calculation corresponds exactly to the exchange of a Z ° between the components of the W+ boson.
- **Binding of the Z° Boson (bd) via W Exchange:**
  The state bd polarizes the vacuum bpdq according to its own chiral polarity:
  (bd) + Vacuum(bpdq) -> (b...d) + W+(pb) + W-(qd)
  The rearrangement shows:
  (b + qd -> d + bq) and (d + bp -> b + pd) -> (db) + Vacuum(bqpd)
  The vacuum remains invariant, while b and d exchange positions. This corresponds exactly to the exchange of a W boson between the components of the Z° boson.
  A photon can similarly emerge through synthesis directly from b and q. During the unification into a photon or a W boson, an intrinsic orbital spin parallel to the spins of the components is generated in the process. For the Z° boson, however, no orbital spin is generated.

Ways of W generation

4.2 Resolution of the Preon Fine-Tuning Problem

The binding between the components of the W boson requires the mass of the Z boson, and the binding of the Z boson requires the mass of the W boson. Therefore,

the sum of both macroscopic masses corresponds directly to their combined binding energy. This immense energy is capable of neutralizing the repulsion of two neutrinos at an extremely short distance (approximately 10 to the power of -18 meters). The generation energies are given by:
Energy(neutrino) - Mass(W) = Mass(Z) and Energy(neutrino) - Mass(Z) = Mass(W)

Mass of the electron: The electron formula **qdb** reveals that it contains the Z°signature as **db** and the W- signature as **qd**. It may seem preposterous that a particle with a net mass of only 0.511 MeV requires an energy of approximately 171 GeV to hold it together. However, within the framework of this model, this is precisely the energy required to induce a fundamental neutrino spin-flip from component **q** to component **d**.
However the binding energy oft he combined Masses of W and Z°, while it absorbs the naked energy oft he forming W and Z masses, does not simply vanish. It is converted to electrical Charge which means it is the energy equivalent of electrical charge 1. Until now electrical charge has been treated as free of energy. It was just a quantum number with power behind it. (see note below)

How can vector bosons be created from a head on collision of 2 Neutrinos?

vector bosons within this model. When discussing a direct head-on collision synthesis:

1. For the **W bosons (bp)** and the **Photon (bq)**, the intrinsic spins of their respective elementary components are aligned anti-parallel, netting a structural spin of 0. To manifest as physical Spin-1 vector particles, the collision process must inherently generate an **orbital angular momentum (orbital spin) of 1**.
2. For the **Z0 boson (bd)**, the intrinsic spins of components **b** (1/2) and **d** (1/2) are already parallel. Consequently, their spins naturally add up to **Spin 1** upon synthesis, making an additional orbital spin mechanically redundant.
3. In the alternative scenario (maintaining Electrical Charge conservation) of **vacuum excitation**, where the neutral vacuum (bpdq) is polarized and decays into opposite charges (an electron-positron pair), the Spin 1 of the emergent W boson or photon is dictated by the law of conservation of angular momentum. As the charged particles separate at high velocities, their relative kinetic motion translates into a quantized field excitation within the surrounding medium. This spatial displacement deposes energy into the vacuum exclusively in integer units, naturally endowing the newly formed gauge bosons with their characteristic Spin 1.

4.3 Compulsory Note:
This paper highlights a fundamental, statistical distinction indicating that electric charge energy equivalent is different from mass energy, as it does not translate into a mass equivalent (which would otherwise falsely dictate an electron mass of approximately 171 GeV). Conceptually, mass-based energy and electric charge energy relate to each other analogously to real and imaginary numbers, fundamentally rooted in their contrasting sign-rules under force definitions. While this work focuses on the statistical and structural foundations of the bpdq-model, it explicitly invites the scientific community to further develop the underlying complex mathematics. Integrating these sign-rules into the relativistic energy-momentum.mass relation and electrical charge flux may open a promising avenue toward the unified field framework historically envisioned by Einstein.

4.4 Epistemological Consideration of the Timeless Binding State

The heavy vector bosons (W, Z) and the top quark are so short-lived that they cannot be understood as static "particles" in the classical sense. They represent a dynamic state of transition—a "state of wanting to become" (Zustand des Werdenwollens)—whose final topological resolution is exactly what constitutes the completed, stable state (such as the electron).

The resulting W-Z system implies a complex, timeless entanglement of the elementary components within the vacuum. The mathematical formalism of this model therefore serves as a structural metaphor for a process for which no classical, measurable duration is available in physical reality. Nevertheless, thought of from its stable end, the model describes exactly the algebraic result of what has manifested within time.

5. Particles with Two States (2-State-Particles) and Quark Colors

To maintain clarity, only one half of the particle table is presented. The complementary half (the antiparticles) is generated by the combined transformations: b <-> q and p <-> d. This is equivalent to swap of Chirality

All 2-state fermions consist of one fermionic state (odd number of components) and one bosonic state (even number of components). This yields two fundamental configurations:

1. The 3-component set: Formula a * aa
2. The 5-component set: Formula aaa * aa

The total sum formula follows the principle of maximum chirality symmetry:
N_b + N_p = N_q + N_d + 1 (For antiparticles: N_b + N_p = N_q + N_d - 1)

Using the shorthand notation where bap stands for b or p, and qad stands for q or d, the 3-component set contains exactly 4 possible particles with the sum formula (bap)2 (qad)1:

Be reminded that flip of all spins in one particle results in the same particle changing direction or being viewed in inverted frame of reference
for easy reading: a State containing bp or qd carries electrical charge +1 resp. -1

- **1. b * bq = p * pd:** Pauli-blocked, internal exchange of components possible without violating the exclusion principle does not change the particle. No mixing of b/q with their mirror images p/d occurs -> **Massless Lepton**.
- **2. b * pq = p * bd:** Chirally mixed -> **Massive Quark-Isomer (Color: Red)**, Q = 0.
- **3. q * pb = d * pb:** Chirally mixed -> **Massive Quark-Isomer (Color: Green)**, Q = +1.
- **4. p * qb = b * dp:** Chirally mixed -> **Massive Quark-Isomer (Color: Blue)**, Q = 0.
The difference between the lepton and the quark colors lies strictly in the spin configuration. States 2, 3, and 4 can transition into one another by exchanging components between the two states. The bosonic part contains the signatures of the Z boson (bd), W boson (pb), and the Photon (qb). The sum of the charges of the three isomers is 0 + 1 + 0 = +1. Statistically, this distributes to the fractional charge of **Q = +1/3**, representing the colors of the **anti-down quark**.

While all 4 Particles have identical chiral composition one has a helical composition b_2q and the other 3 have helical composition bpq

5.1 The 5-Component Set: The Up-Quark Family

Following the chiral sum formula (bap)3 (qad)2, the structural configuration aaa * aa yields:

1. bpd * pd = pbq * bq (Q = +1) -> Massive state due to opposing chiralities within its structure. Helical formula b_1 p_2 d_2
- The helical formula oft he following structures 2 to 4 is b_1 p_2 q_1 d_1
2. bpd * pq = pbq * bd (Q = +1) -> **Quark-Isomer (Color: Red)**
3. bpq * pd = pbd * bq (Q = +1) -> **Quark-Isomer (Color: Green)**
4. dqp * bp = qdp * pb (Q = 0) -> **Quark-Isomer (Color: Blue)**

The sum of the charges over the three colors is 1 + 1 + 0 = +2. Statistically, this yields the quark charge of **Q = +2/3**, representing the **up quark**.

5.2 The Gauge Bosons of the Strong Interaction: Gluons

The interaction of quark colors is driven by the exchange of gluons. For a component to switch states, it must disappear from one side and appear on the other. This

requires a boson composed of an elementary component and an anti-elementary component (EC * anti-EC). The four fundamental combinations are:
b * anti-b, q * anti-q, d * anti-d, p * anti-p or b*q,q*b,d*p,p*d
Since the direction of flight can change (e.g., red to green or green to red), these 4 combinations naturally generate the **8 gluons** of the strong interaction.

5.3 Solution to the Up-Down Mass Anomaly

In the Standard Model, the fact that the down quark is heavier than the up quark is an unexplained constant. The bpdq model reveals two structural causes for this phenomenon based on symmetry violation:

1. **Chiral Ratio:** The up quark has a balanced ratio of (b,p) to (d,q) of 2:3, while the down quark exhibits a highly asymmetric ratio of 1:2.
2. **Charge Distribution:** In the up quark, charge is distributed as 1, 1, +1-1= 0. **Note that even the uncharged color has a plus and a minus charge in its structure.**
   In the down quark, it is severely concentrated as 0, 1, 0. This extreme asymmetry causes a stronger local polarization of the vacuum, resulting in a higher effective macroscopic mass for the down quark.

6. Particles with Three States (3-State-Particles) and the Generation Limit

3-state fermions necessarily possess 5 or 7 component particles. The two bosonic states allow three configurations based on spin orientation:

- **Configuration A:** Both bosonic states follow the spin alignment of the fermionic state. These are tau neutrino (5 components) and Tau Lepton (7 Components)
  p* pq*pq for the tau neutrino, bpd*pd*pd yield the Tau lepton
- **Configuration B:** One bosonic state follows the alignment, the other is spin-flipped.
- **Configuration C:** Both bosonic states are polarized opposite to the fermionic state.

6.1 The 5-Component Set (a * aa * aa) under Configuration B (6-Color Quarks)

- b * pd * bq (Q = 0, Color: Red-Red)
- b * pb * dq (Q = 0, Color: Green-Green)
- b * pq * bd (Q = 0, Color: Blue-Blue)
- p * bd * bq (Q = 0, Color: Blue-Red)
- q * bp * bd (Q = +1, Color: Green-Blue)
- d * bp * bq (Q = +1, Color: Green-Rot)

This family exhibits a highly complex multi-color structure representing the heavy quark generations (**Strange or Bottom**).

6.2 Configuration C and State Migration: The Collapse into 3 Colors

Under Configuration C, the complex multi-color states spontaneously migrate into the stable 3-color symmetry via the migration of components between states:

- **For the Bottom/Strange Quark (a * aa * aa -> aaa * a * a):**
  b * bq * qd -> bqd * b * q (Q = -1)
  q * bd * bq -> qdb * b * q (Q = -1)
  d * bq * bq -> dbq * q * b (Q = -1)
- **For the Top/Charm Quark (aaa * aa * aa -> aaa * aaa * a):**
  bpd * bq * bq -> bpq * bdq * b (Q = 0)
  bpq * bd * bq -> bpq * bdq * b (Q = 0)
  bdq * bp * bq -> bdq * bpq * b (Q = 0)
  Following this algebraic redistribution, the new structures become identical in color and charge, explaining why quarks must transition into color-neutral hadrons.

6.3 The Structural Singularity and Mass of the Top Quark

For all regular fermions, the condition of maximum chirality symmetry holds:
abs(N(bap) - N(qad)) = 1.
However, on the level of helicity, the top quark structure (b3pdq2) is the **only state in the entire model** where this symmetry is broken radically, yielding:
abs(N_b - N_p) = 2 (and spiegelbildlich abs(N_q - N_d) = 2 for the anti-top quark)

This singular helicity asymmetry causes maximum topological resistance against the regular vacuum, suggesting the immense mass of the top quark (~173 GeV) and marking the absolute mathematical boundary of stable matter.

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7. Gravity

7.1 Vacuum Activation: The Birth of Gravitons

When high energy is applied from the outside to the neutral vacuum (bpdq), two adjacent vacuum cells interact directly with each other (bpdq + bpdq). Through a collective exchange of components followed by parallel spin alignment, the system reorganizes itself.

The result of this high-energy excitation is the birth of two gravitons with a total spin of 2. Each of these two gravitons is a deeply entangled, bosonic dual system consisting of two distinct photon-like states:

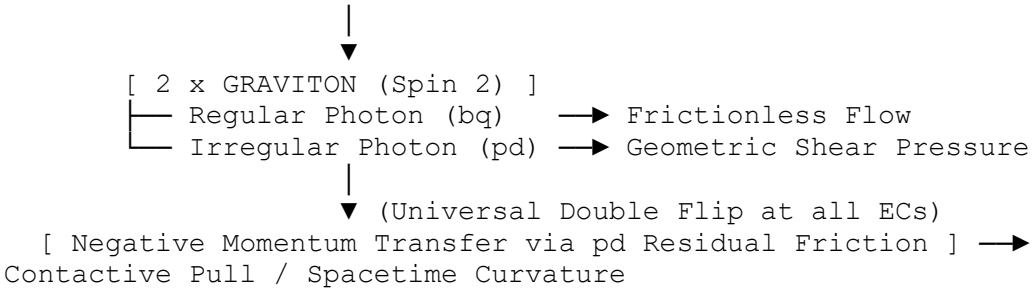
1. **A regular photon (bq):** Composed of the forward-rotating components (forward propellers) that move harmoniously within phase space [1.6].
2. **An irregular photon (pd):** Composed of the components (backward propellers) that are forced against their own blade geometry under high internal shear pressure [1.6].

4.2 The Principle of Universal Coupling via the Double Flip

Throughout the history of physics, there have been repeated attempts to calculate gravitation as a tiny residual effect of electrical attraction and repulsion. These attempts failed because gravity also affects non-charged Neutrinos. Our model breaks radically with this approach: gravitation is not an electromagnetic byproduct; it acts at a deeper level.

Since the graviton is composed of the primordial letters of space, it interacts with any b, p, d, q state—albeit with an extremely low amplitude. The mechanism occurs via a double flip:

- The graviton strikes a particle (e.g., a neutrino of matter or a component of the vacuum itself).
- It forces the elementary components (ECs) of the struck state to undergo a simultaneous structural inversion.



7.2 Differential Asymmetry and the Neutrino Connection to the Standard Model

The interaction between photons and neutrinos is indeed so unimaginably weak that established physics completely negates it in everyday contexts. Yet, as a mechanism for gravitation, this minuteness is not only sufficient but mathematically mandatory [3.8].

The attractive (contractive) effect of gravity emerges in our model as a pure differential effect between the regular (bq) and the irregular (pd) photon:

- The regular photon (bq) glides completely without friction through the vacuum matrix.
- The irregular photon (pd) runs backward and generates a minimal, infinitesimal residual friction .This results in a tiny momentum deficit: the negative momentum of the pd-system is marginally greater than the positive momentum of the bq-system. During the double flip, a net negative momentum transfer remains—the vacuum contracts.
Here, the bridge connects to the latest discoveries of the Standard Model (SM):
Modern physics has proven beyond doubt through neutrino oscillations that neutrinos must possess a minimal, non-zero mass. Furthermore, the SM is puzzled by the hypothetical existence of "wrong-handed" (sterile, right-handed) neutrinos.

Since the vacuum component are subject to this double flip, the same is true fort he vacuum state. Geometric space curvature ist he Result. The presence of mass provides the energy required to trigger he birth of gravitones from adjacent vacuum.

7.3 Gravity as a Function of Vacuum Frequency

Since there is no empty space, light propagation is understood as the transmission of states between immediately adjacent vacuum components (bpdq). The energy of the vacuum state is defined by a local oscillation frequency.

Where matter is present, the vacuum is compressed and polarized by the irregular components and the Higgs boson (the massive scalar excitation of the bpdq vacuum). This concentration of energy increases the local flactuation frequency of the vacuum.

7.2 Deflection of Light

An increased vacuum frequency creates a higher density of interaction, which acts as an increased physical resistance (inertia) for a passing photon (bq). Consequently, the effective velocity of light decreases in the vicinity of large masses (Shapiro delay). Just as a light wave is deflected toward the optically denser medium when passing from air into glass, light is deflected toward the center of a mass. Gravitational space curvature is thus revealed to be the localized variation of the intrinsic oscillation frequency of the bpdq vacuum medium.

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