

From Sources and Sinks to the Standard Model: A Rotor–Division-Algebra Construction of Particle Structure, with a Computational Ledger of What Is Forced and What Is Not

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Abstract

We develop a single geometric premise—the imaginary unit read as a rotation generator (a *rotor*), with a *source* and a *sink* as its two fixed points—into an explicit construction of the discrete structure of the Standard Model (SM). A particle is modeled as a self-sustaining source–sink circulation; its charge is the pump direction, its spin the double-cover class of the rotor group, its hypercharge a net source/sink flux count, and its mass the winding density of a topological soliton. Combined with the division-algebra tower $\mathbb{C} \otimes \mathbb{H}$ (weak) and $\mathbb{C} \otimes \mathbb{O}$ (color and charge) and its exceptional Jordan closure $\mathfrak{J}_3(\mathbb{O})$ (the 27-dimensional Albert algebra with automorphism group F_4), this reproduces, computationally and without free parameters: color $SU(3)$; the electric-charge spectrum $\{0, 1/3, 2/3, 1\}$; the weak doublet with $I_3 = \pm 1/2$; the number of colors $N_c = 3$; a single generation (not three) via $Spin(8)$ triality; spin-1/2 and Fermi statistics from the quaternion group Q_8 ; the full hypercharge spectrum of one generation as a rigid integer flux-count pattern with zero free parameters, sealed by the vanishing of both anomaly traces at $N_c = 3$; and the nucleon as a soliton whose stabilizing term is *derived* as the area strain-invariant of the rotor map, reproducing the Adkins–Nappi–Witten couplings. On the discrete-symmetry side we prove a positive and a negative result: a CP-odd invariant *exists* and is the three-rotor geometric (Bargmann) phase, equal to the solid angle of the rotors’ spherical triangle—the same object as the CKM unitarity-triangle area; whereas parity violation *cannot* arise from the construction, a CP-lock we establish four independent ways. The Weyl chiral split itself is *derived* from the fluid boost (the transformation law of the current’s spinor square-root, $\psi_R' = B\psi_R$, $\psi_L' = B^{-1}\psi_L$), and complexifying $\mathfrak{J}_3(\mathbb{O}) \rightarrow \mathfrak{J}_3(\mathbb{O}) \otimes \mathbb{C}$ (structure group E_6) makes a chiral generation representable rather than impossible. The QCD scale, the Yukawa sector, and the orientation of parity (a single input, unified by *CPT*) remain input—exactly as they do in the Standard Model. Every claim carries an executable verification and a ledger tag: FORCED, INPUT, or NEGATIVE.

Introduction

The Standard Model organizes roughly nineteen free parameters and assigns chirality by hand; it does not explain any of these choices. A natural and answerable question is how much of its *discrete*, parameter-free structure—the gauge group, the charge spectrum, the color count, the spin–statistics of matter—can be traced to a single geometric origin. This paper pursues one such origin: the source–sink–rotor.

The premise is that the imaginary unit is not an abstract $\sqrt{-1}$ but the generator of a rotation, in the sense of geometric algebra. On the extended complex plane (the Riemann sphere) a rotation has two fixed points, which we read physically as a *source* and a *sink*; the flow between them, twisted by the rotational part of the generator, is the elementary object we build from. Everything downstream is then either compelled by this premise together

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with the standard division-algebra constructions, or it is not—and we are equally careful about both.

Method.

We keep a strict ledger. Each result is tagged FORCED (compelled by the geometry given only the source–sink–rotor premise and the division-algebra tower), INPUT (a genuine assumption or free parameter, in which case we state whether the SM shares it), or NEGATIVE (a proposed identification we prove cannot hold). Every tag is backed by a calculation the reader can rerun; the numbers quoted below were produced in a single verification pass and are described in the text where they appear. The discipline is not decorative: several appealing ideas examined during this program were rejected on explicit technical grounds (dimensional inconsistency, integer fitting, or misread identities), and the credibility of the forced results rests on the failures being named where they arise.

Positioning.

The algebraic constructions are not original here. Color and charge from complexified octonions are due to Günaydin–Gürsey and Dixon; the single-generation ideal to Furey and Furey–Hughes; the $Cl(6)$ route to Stoica; the exceptional Jordan algebra to Jordan–von Neumann–Wigner and Albert, and its use for the SM group to Dubois-Violette, Todorov, and Boyle; the soliton description of the nucleon to Skyrme, Witten, Adkins–Nappi–Witten, Manton, and Goldstone–Wilczek. Our contributions are: (i) the source–sink–rotor synthesis and the particle-by-particle emergence of Sec. 6; (ii) the hypercharge-as-flux-count result (Sec. 6.2); (iii) the strain derivation of the Skyrme stabilizer (Sec. 7); (iv) the three-rotor Bargmann invariant as the geometric origin of CP-violation structure (Sec. 8.2); and (v) the boundary theorems of Sec. 9.

The Source–Sink–Rotor Ontology

Rotor, source, and sink

Let $z \in \mathbb{C} \cup \{\infty\}$ coordinatize the Riemann sphere. A Möbius flow

$$f(z) = \frac{z+1}{z-1}, \quad z(t) = e^{t(1+i)} z_0,$$

has a source at one pole and a sink at the other; the real part of the generator (1) drives the radial source-to-sink transport, while the imaginary part (i) rotates the streamlines as they travel, bending them into a loxodromic spiral. This is the elementary rotor: a fluid vortex with no solid core, a source pole from which flux erupts, a sink pole into which it drains, and a circulation set by the rotational part of the generator. There is no particle “object”—only the self-sustaining circulation.

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One rotor is $SU(2)$, not S^2

The state space of a single rotor is the group $SU(2) = Sp(1) = S^3$ of unit quaternions, not the two-sphere $S^2 = SU(2)/U(1)$ of mere *directions*. This distinction is load-bearing: S^2 is simply connected ($\pi_1 = 0$) and cannot carry spin-1/2, whereas $SU(2)$ does. The three rotational axes are the three generators i, j, k of $\mathfrak{su}(2) = \text{Im}\mathbb{H}$ —one rotor with three axes, not three rotors.

The dictionary

The physical attributes of a particle are read off the rotor as follows; each entry is made precise and verified in the indicated section.

Attribute	Rotor reading	Section
Particle	self-sustaining source–sink circulation (a vortex)	2
Charge	pump/circulation direction (sign of the imaginary part)	2.4
Hypercharge	net source/sink flux count	6.2
Spin	double-cover class of the rotor group, $-1 \in Q_8$	3
Mass	winding density of the soliton	7
Color	index on the internal $\mathbb{C}^3$ / octonionic ladder	4.2
Antiparticle	complex conjugation, $z \mapsto \bar{z}$ (circulation reversed)	2.4

Charge conjugation is complex conjugation

The map $z \mapsto \bar{z}$ reflects across the real axis, reversing the imaginary part and hence the circulation. Physically it reverses the pump: source $\leftrightarrow$ sink, i.e. particle $\leftrightarrow$ antiparticle. This identifies charge conjugation C with complex conjugation. It also fixes the algebraic type of the two attributes: the complex structure J defining charge satisfies $J^2 = -1$, while chirality γ^5 is a *real* structure, $(\gamma^5)^2 = +1$, with $\gamma^5 = iJ$. This pairing is the seed of both the CP result (Sec. 8.2) and the parity obstruction (Sec. 8.3).

Spin from the Double Cover

The four distinguished points $\{-1, 0, 1, \infty\}$ on the rotor sphere form a harmonic range (cross-ratio 2), whose rotational stabilizer is the Klein four-group V_4 of π -rotations about the three axes. Its preimage under the double cover $SU(2) \rightarrow SO(3)$ is the quaternion group

$$Q_8 = \{\pm 1, \pm i, \pm j, \pm k\}.$$

Realizing the covering explicitly (via the quaternion-to- $SO(3)$ conjugation map) confirms it is exactly 2:1: the eight elements of Q_8 map onto the four elements of V_4 , with $\{+1, -1\}$ both projecting to the identity rotation. The central element $-1 \in Q_8$ is the 2π rotation: it

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differs from $+1$ although both project to the identity of $SO(3)$. Thus a full 2π turn does not restore the rotor; only 4π does. This is spin-1/2, present in the marked set itself rather than assigned. Quantizing the collective rotation of the soliton (Sec. 7) yields the tower $E_j = M + 1/2 \Lambda j(j+1)$ with $J = I$, and the half-integer sector is selected by the sign $\varepsilon = (-1)^{N_c}$ under the 2π loop, which is -1 precisely because $N_c = 3$ is odd. Spin-1/2 and Fermi statistics are FORCED, hinging on the same N_c as the charge sector.

The Division-Algebra Tower

$\mathbb{C} \otimes \mathbb{H}$: the weak doublet and I_3

The complexified quaternions satisfy $\mathbb{C} \otimes \mathbb{H} \cong M_2(\mathbb{C})$. A minimal *left* ideal is a single column and carries the fundamental (doublet) representation of the weak generators $T_a = 1/2 \sigma_a$; the Cartan T_3 has eigenvalues $\pm 1/2$ on the ideal. This is the weak doublet with $I_3 = \pm 1/2$ read off directly. By Schur's lemma the commutant of this irreducible doublet inside $M_2(\mathbb{C})$ is one-dimensional, so $\mathbb{C} \otimes \mathbb{H}$ possesses exactly one $U(1)$ beyond $SU(2)$, it is central, and its *value is unfixed*. The hypercharge normalization is therefore not available from $\mathbb{C} \otimes \mathbb{H}$ alone; it is supplied by the octonionic sector (Sec. 6.2).

$\mathbb{C} \otimes \mathbb{O}$: color and the charge ladder

Choosing a complex structure in the octonions reduces $G_2 = \text{Aut}(\mathbb{O})$ to $SU(3)$ (its stabilizer) and produces a Witt/ladder basis $\alpha_1, \alpha_2, \alpha_3$ of three fermionic modes on the $2^3 = 8$ -dimensional minimal ideal. The number operator

$$N = \sum_{i=1}^3 \alpha_i^\dagger \alpha_i$$

has integer eigenvalues $\{0,1,2,3\}$ with multiplicities $\{1,3,3,1\}$ (verified by direct diagonalization of the Jordan-Wigner realization). Each raising operator increments N by one, and electric charge is

$$Q = \frac{N}{3} \in \{0, 1/3, 2/3, 1\},$$

i.e. a neutrino ($Q = 0$), a color triplet at $1/3$, a color triplet at $2/3$, and a positron ($Q = 1$). The two triplets are the $N_c = 3$ colors. Color $SU(3)$ and the fractional charge quantum are FORCED; note that the fractions reside in the definition $Q = N/3$, while N itself is integer-valued—a distinction that matters in Sec. 9. The charge spacing is exactly $1/3$ because each ladder step raises N by one; this fixes the charge *ratios* within a multiplet.

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The Exceptional Jordan Algebra: $n = 3$ Is Maximal

Jordan algebras are the algebraic form of quantum observables: Hermitian quantities with the symmetric product $A \circ B = 1/2 (AB + BA)$, subject to the Jordan identity

$$(A \circ B) \circ A^2 = A \circ (B \circ A^2),$$

the minimal condition guaranteeing a spectral theory. For Hermitian $n \times n$ octonionic matrices, the Jordan identity holds only for $n \leq 3$. Building the octonions by Cayley–Dickson doubling and testing it on random Hermitian matrices, the maximal violation is

$$\text{residual}(n = 2) \approx 3 \times 10^{-14}, \quad \text{residual}(n = 3) \approx 4 \times 10^{-14}, \quad \text{residual}(n = 4) \approx 2 \times 10^2.$$

The identity holds to machine precision at $n = 2, 3$ and shatters at $n = 4$. Hence $n = 3$ is not a choice: it is the maximal size at which octonionic Hermitian matrices form a Jordan algebra, the unique exceptional (Albert) algebra

$$\mathfrak{J}_3(\mathbb{O}), \quad \dim = \underbrace{3}_{\text{real diag.}} + \underbrace{3 \times 8}_{\text{octonionic}} = 27,$$

with automorphism group F_4 . This is forced by the *existence* of the algebra, a stronger sense than any representation-dependent count.

The cubic characteristic form

The canonical $3 + 24$ decomposition above is not merely a dimension count: because the elements are 3×3 , every $X \in \mathfrak{J}_3(\mathbb{O})$ satisfies a *cubic* characteristic equation

$$X^3 - (\text{Tr}X) X^2 + \sigma(X) X - \det(X) \mathbf{1} = 0,$$

whose coefficients are the three basic invariants—the trace, the quadratic form σ , and the Freudenthal cubic det. A Hermitian element therefore has exactly three real eigenvalues. This is the algebraic origin of the three-fold structure used in Sec. 9.3: the spectrum of any observable in $\mathfrak{J}_3(\mathbb{O})$ is a triple, and the trigonometric (Viète) solution of this cubic is precisely the circulant form.

Two roles, kept distinct

The construction uses $\mathfrak{J}_3(\mathbb{O})$ (and its complexification) in two logically separate ways, and the distinction matters because conflating them produces false conclusions.

1. *As a representation.* The complex **27** of E_6 carries fermion content: one chiral generation together with the exotic $\mathbf{10} \oplus \mathbf{1}$ (Sec. 9.2). Chirality requires this reading, because only a complex representation can host a chiral generation.
2. *As an algebra of observables.* Elements of $\mathfrak{J}_3(\mathbb{O})$ are Hermitian operators; the cubic the cubic characteristic equation gives three real eigenvalues, and this is the reading relevant to the mass spectrum.

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Both readings are legitimate— $\mathfrak{J}_3(\mathbb{O})$ was introduced by Jordan, von Neumann and Wigner precisely as an algebra of observables—but they are not interchangeable. In particular the three eigenvalues of role (2) are *not* the three copies of the **27** that a three-generation model requires in role (1); the **27** is one generation (Sec. 6.3), and its diagonal entries are not a family index.

The distinction is visible as two different decompositions of the same 27:

$$\begin{aligned} 27 &= \underbrace{3}_{\text{real diagonal}} + \underbrace{24}_{3 \times 8 \text{ octonionic off-diagonal}} && \text{(matrix structure; gives the cubic),} \\ 27 &= 16 \oplus 10 \oplus 1 && \text{(branching under } SO(10); \text{ gives the particle content).} \end{aligned}$$

The first is a statement about $\mathfrak{J}_3(\mathbb{O})$ as an algebra and underlies the mass spectrum (Sec. 10); the second is a statement about how E_6 acts and underlies the predicted spectrum (Sec. 11). Neither substitutes for the other: the 24 off-diagonal components are octonionic components of matrix entries, not particles, and the branching is not a matrix structure and yields no characteristic polynomial.

Emergence of the Standard-Model Particles

We now assemble one generation. Two forced quanta drive everything: the octonionic charge step $1/3$ (Sec. 4.2) and the quaternionic isospin $\pm 1/2$ (Sec. 4.1).

$N_c = 3$ from charge-trace freedom

The electric charges of one generation sum to zero only for three colors:

$$\sum Q = (0 - 1) + N_c(2/3 - 1/3) = -1 + \frac{N_c}{3} = 0 \Leftrightarrow N_c = 3,$$

verified as $\sum Q = -1/3, 0, +1/3$ for $N_c = 2, 3, 4$. This is the charge-quantization avatar of $N_c = 3$, independent of and consistent with the color-triplet count. FORCED.

Hypercharge as a source/sink flux count

In the source–sink picture a source contributes $+1$ unit of flux and a sink -1 ; the net flux of a state is a $U(1)$ charge, which we identify with hypercharge in units of the octonionic $1/3$. Concretely, with Q from the octonionic ladder and I_3 from the quaternionic doublet, the Gell-Mann–Nishijima relation $Q = I_3 + Y/2$ gives

$$Y = 2(Q - I_3), \quad \text{net flux} = 3Y.$$

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Table 1 lists the full generation. The key observation is that every hypercharge lies in $1/3 \mathbb{Z}$ with *no free parameter*: normalized to the smallest nonzero value, the six hypercharges form the rigid integer pattern $\{-6, -3, -2, 0, 1, 4\}$. The hypercharge *ratios* are therefore FORCED by the two quanta, not six independent inputs.

One generation as source/sink flux counts. Q is forced by the octonionic ladder, I_3 by the quaternionic doublet; $Y = 2(Q - I_3)$, net flux $= 3Y$.

Field	color	I_3	Q	Y	net flux $3Y$
$Q_L = (u, d)_L$	3	$\pm 1/2$	$2/3, -1/3$	$1/3$	+1
u_R	3	0	$2/3$	$4/3$	+4
d_R	3	0	$-1/3$	$-2/3$	-2
$L_L = (v, e)_L$	1	$\pm 1/2$	$0, -1$	-1	-3
e_R	1	0	-1	-2	-6
v_R	1	0	0	0	0

Moreover the pattern is anomaly-sealed. Over one generation (left-handed Weyl counting)

$$\sum Y = 0, \quad \sum Y^3 = 0,$$

and the cubic trace vanishes *only* at $N_c = 3$ (+2 at $N_c = 2$, -2 at $N_c = 4$). The same integer, $N_c = 3$, that fixes the charge step also seals both anomaly conditions. What is *not* forced is the chiral labeling—that the left-handed fields are the doublets—which is the parity input of Sec. 8.3.

One generation, not three (triality)

The three off-diagonal slots of $\mathfrak{J}_3(\mathbb{O})$ are not a family index. $Spin(8)$ triality relates the vector 8_v and spinors $8_s, 8_c$, and the exceptional three is the $8_v \oplus 8_s \oplus 8_c$ architecture of a *single* generation, confirmed by a rank obstruction: $\text{rank} F_4 = \text{rank} Spin(8) = 4$ is maximal, leaving no room for an independent family symmetry inside F_4 . The family three, when it appears (e.g. $E_8 \supset E_6 \times SU(3)$), is a choice among maximal subgroups. FORCED (one generation); the family index is INPUT.

Forced-results ledger for particle structure. Every entry is verified.

Result	Origin	Evidence
$n = 3, \dim \mathfrak{J}_3(\mathbb{O}) = 27$	Jordan identity shatters at $n = 4$	residual $10^{-14} \rightarrow 10^2$
Color $SU(3)$, $Q \in \{0, 1/3, 2/3, 1\}$	$\mathbb{C} \otimes \mathbb{O}$ minimal ideal	spectrum $\{1, 3, 3, 1\}$
Weak doublet, $I_3 = \pm 1/2$	$\mathbb{C} \otimes \mathbb{H}$ left ideal	T_3 eigenvalues
$N_c = 3$	charge-trace freedom	$\sum Q = 0 \Leftrightarrow N_c = 3$
Hypercharge pattern $\{-6, -3, -2, 0, 1, 4\}$	$Y = 2(Q - I_3)$, flux count	no free parameter

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Result	Origin	Evidence
$\sum Y = \sum Y^3 = 0$	anomaly cancellation	only at $N_c = 3$
One generation	$Spin(8)$ triality, rank obstruction	$\text{rank} F_4 = 4$
Spin-1/2, Fermi statistics	double cover, $-1 \in Q_8$	$8 \rightarrow 4, (-1)^{N_c}$
Charge quantization	$\pi_1(U(1)) = \mathbb{Z}$ circulation	integer winding (Sec. 9.1)
Fractional charges in thirds	$\mathbb{Z}_3$ centre quotient	centre-to-fraction law

The Nucleon as a Soliton, with a Derived Stabilizer

Read as a map $R: \mathbb{R}^3 \rightarrow SU(2)$, the rotor field carries a topological charge $B \in \pi_3(SU(2)) = \mathbb{Z}$, the winding number, identified with baryon number. The energy must be built from the first-order strain of the map, encoded in the symmetric tensor $D_{ij} = \langle \partial_i R, \partial_j R \rangle$ with eigenvalues (squared principal stretches) $\lambda_1^2, \lambda_2^2, \lambda_3^2$. The only rotation- and target-invariant local densities are the elementary symmetric polynomials of the stretches:

$$\begin{aligned} e_1 &= \sum_a \lambda_a^2 && (\text{kinetic}, E_2), \\ e_2 &= \sum_{a < b} \lambda_a^2 \lambda_b^2 && (\text{Skyrme term}, E_4), \\ \sqrt{e_3} &= \lambda_1 \lambda_2 \lambda_3 && (\text{baryon density}). \end{aligned}$$

The Skyrme stabilizer is thus *not* an ad hoc quartic: it is the unique four-derivative, “area” strain-invariant e_2 , and it is the lowest term that stabilizes the soliton against Derrick collapse (two derivatives scale as λ^{-1} , four as λ^{+1}). We verified that the commutator Skyrme density equals e_2 and the baryon density squared equals $9/4 e_3$, identically. Solving the hedgehog profile equation

$$(x^2 + 2\sin^2 F)F'' + 2xF' + \sin 2F (F')^2 - \sin 2F - \frac{2\sin^3 F \cos F}{x^2} = 0, \quad F(0) = \pi, F(\infty) = 0,$$

gives $B = 1$ from the boundary conditions and reduced integrals $\mathcal{E} = 11.608, J = 6.372$, hence

$$M = 4\pi \mathcal{E} \sqrt{c_2 c_4} = 36.47 \frac{F_\pi}{e}, \quad \Lambda = \frac{16\pi}{3} J \frac{c_4^{3/2}}{c_2^{1/2}} = 106.8 \frac{1}{e^3 F_\pi},$$

a factor 1.23 above the Bogomolny floor $12\pi^2 \sqrt{c_2 c_4}$. Fitting the nucleon and Δ masses returns $(F_\pi, e) = (129 \text{ MeV}, 5.44)$, and the parameter-free isoscalar radius is $\sqrt{\langle r^2 \rangle_{I=0}} = 0.60 \text{ fm}$ (83% of experiment), reproducing Adkins–Nappi–Witten. The stabilizer’s *form* is FORCED; its *coefficient* (the length scale) is INPUT (Sec. 9.3).

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Mass and charge: a forced α -suppressed link.

Mass and charge are co-defined by one vortex but are not in a value-fixing relation—the same-charge lepton tower (e, μ, τ at $Q = -1$, masses spanning $3500 \times$) forbids any $m = f(Q)$. The genuine link is subdominant and forced. The spin-1/2 condition (angular momentum $\hbar/2$ carried at speed $\sim c$) fixes the vortex radius at the Compton scale $R \sim \hbar/(mc)$, not the classical radius; evaluating the electromagnetic self-energy there gives

$$U_{\text{charge}} = \frac{\alpha \hbar c}{R} \sim \alpha mc^2,$$

so charge contributes a fixed $\sim 1/137$ fraction of the mass, with the remaining $\sim 99\%$ being winding energy—mirroring the nucleon's $\sim 99\%$ -binding budget. Were mass entirely charge self-energy, the electron radius would be the classical 2.8 fm, which overshoots the pointlike bound by 10^3 ; the spin-fixed Compton radius, $137 \times$ larger, is the correct scale and makes the charge contribution α -suppressed. FORCED (the α fraction); the mass scale itself remains INPUT.

Discrete Symmetries: Chirality, CP, and a Parity Wall

Lorentz chirality from the fluid square-root

The chiral split of the fluid is not the spatial swirl (helicity, frame-dependent) but the transformation law of the current's matrix square-root, which is Lorentz-invariant. The object is a localized rotor residing on a presupposed Minkowski spacetime—the framework does not derive the spacetime background but, like the Standard Model, assumes it and establishes that its states transform correctly upon it. Encode the localized rotor's four-current as the Hermitian matrix $J = J^\mu \sigma_\mu$; under a boost $B = \exp(-1/2 \vec{\xi} \cdot \vec{\sigma})$ (with $B = B^\dagger$, $\det B = 1$) it transforms as $J' = BJB^\dagger$, so the mass is a boost invariant,

$$\det J' = \det J = m^2.$$

The spatial part $\vec{J}$ (helicity) is frame-dependent, but $\det J = m^2$ is not: mass is a genuine Lorentz scalar of the localized current, not of any global medium. Factorizing $J = \psi_R \psi_R^\dagger$ and $\bar{J} = \psi_L \psi_L^\dagger$ gives spinor square-roots that transform as

$$\psi_R' = B \psi_R, \quad \psi_L' = (B^\dagger)^{-1} \psi_L = B^{-1} \psi_L,$$

which are exactly the defining laws of right-handed $(1/2, 0)$ and left-handed $(0, 1/2)$ Weyl spinors of $SL(2, \mathbb{C})$. The distinction between ψ_L and ψ_R is thus the frame-invariant transformation rule of the square-root—not the spatial circulation. The chiral split therefore *exists* and is FORCED from the fluid boost, and the invariant $\psi_L^\dagger \psi_R$ is the (boost-invariant) Dirac mass. What remains INPUT is which chirality the weak interaction couples to (the orientation, Sec. 8.3) and the number of generations (Sec. 6.3); the fluid derives that ψ_L, ψ_R exist and transform correctly, not that only ψ_L couples.

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CP violation: the three-rotor geometric invariant

A single rotor cannot support a CP-odd invariant: its winding is one integer, and the candidate $\mathcal{C} = \oint_{\gamma} d\phi - \oint_{CP(\gamma)} d\phi$ vanishes identically because CP acts on a single winding by two sign flips (circulation reversal and loop reversal) that compose to the identity; $\mathcal{C}$ is CP-even by construction. A genuine CP-odd invariant requires an antisymmetric pairing of *distinct* windings. For three rotor states on the Bloch sphere this is the Bargmann invariant

$$J_{\text{geo}} = \text{Im}(\langle 1|2\rangle\langle 2|3\rangle\langle 3|1\rangle) = (\text{half}) \text{ the solid angle of the spherical triangle } (n_1, n_2, n_3),$$

which is nonzero for non-coplanar rotors, changes sign under a mirror (CP-odd, verified), and vanishes when the three directions are coplanar (verified $\sim 10^{-17}$). This is precisely the Jarlskog structure: the measured CKM invariant equals twice the area of the unitarity triangle, $J = 2 \times \text{area} = 3.0 \times 10^{-5}$, itself a Bargmann invariant. Thus the geometry *forces* the CP-odd structure, and CP violation is *generic* (non-coplanar), with CP conservation the measure-zero coplanar case. FORCED (structure and existence, given three generations). The *magnitude* 3.0×10^{-5} corresponds to a very thin triangle—nearly coplanar rotors, i.e. the small CKM angles—which is the Yukawa sector: INPUT.

Parity violation cannot come from the construction

Parity violation is the coupling of $SU(2)_L$ to the left projector $P_L = 1/2 (1 - \gamma^5)$, whose spectrum $\{0,1\}$ annihilates one chirality. We show it is unreachable four ways.

1. *Algebraic type.* The charge complex structure has $J^2 = -1$ (eigenvalues $\pm i$, symmetric), whereas γ^5 has $(\gamma^5)^2 = +1$; a projector with spectrum $\{0,1\}$ is not a real-linear function $a\mathbf{1} + bJ$ of J (those have spectrum $a \pm bi$).
2. *CP-lock.* With $\gamma^5 = iJ$, flipping $J \rightarrow -J$ flips charge *and* chirality together: it is CP , never P alone.
3. *Vectorlike charge.* $[Q, \gamma^5] = 0$: electric charge (and hence the source/sink structure that defines it) commutes with chirality; QED conserves parity, so the charge construction is parity-blind by design.
4. *Flux count.* A source/sink count is a $U(1)$ charge; it acts on charge content, not on spatial handedness. A real source/sink flow is irrotational (zero circulation, verified), so it carries no handedness for P to reverse.

Maximal parity violation is therefore an irreducible INPUT, and this is a **NEGATIVE** result about the mechanism. The Standard Model likewise assigns chirality by hand.

The input has a home: a chiral vacuum condensate.

That parity is input does not leave it unexplained; it locates it in the vacuum, exactly as in the Standard Model. Parity violation can be carried by a *chiral condensate*—a vacuum expectation value that is not symmetric under $Y \rightarrow -Y$ —which couples the left and right

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sectors asymmetrically. This is precisely the rôle of the Higgs condensate in the SM, where parity violation and mass both originate in a vacuum that distinguishes ψ_L from ψ_R (the mass term $\bar{\psi}_L \psi_R$ requires both, and the chiral coupling selects one). In the fluid picture the analogous object is a background twist of the vacuum; positing it *implements* parity violation but does not *derive* it, because the condensate's handedness is put in—the same single orientation input, now identified with a vacuum structure of the same character as the Higgs. We emphasize the distinction from helicity: the condensate acts on the Lorentz-invariant chirality (the square-root transformation type of Sec. 8.1), not on the frame-dependent spatial swirl, so the mechanism is relativistically consistent. INPUT, shared with the SM.

The discrete-symmetry orientations reduce to one input (CPT)

The three discrete-symmetry orientations are not independent. The *CPT* theorem forces the antiunitary operator $\Theta = CPT$ to be a symmetry, and in the chiral basis it commutes with chirality, $[\Theta, \gamma^5] = 0$ (verified), whereas parity anticommutes with it, $\{\gamma^0, \gamma^5\} = 0$. Thus *CPT* preserves the left/right label—it maps a left field to a left field—and is blind to which chirality couples: it holds identically for a left-coupled and a right-coupled theory (verified), which is why the maximally parity-violating Standard Model is *CPT*-invariant. Consequently *CPT* cannot fix the parity orientation, and in a single- $\mathbb{C}^2$ (Weyl) model it cannot even represent $P = \gamma^0$, an off-diagonal operator requiring the full Dirac $\mathbb{C}^4 = \mathbb{C}_L^2 \oplus \mathbb{C}_R^2$; no product of the chirality-preserving fluid operations (C = pump reversal, T = spin flip) reproduces the block-swapping γ^0 (verified). What *CPT* *does* provide is a relation: with Θ fixed, the orientations of P , C , and T are locked together, so the discrete-symmetry sector carries a *single* orientation input rather than three, and that input coincides with the CP phase of Sec. 8.2. FORCED (the reduction to one input); INPUT (the input itself, shared with the SM).

The Boundary: Impossibility Theorems

Charge and baryon number are windings of different degree

Both electric charge and baryon number are topological, but they are windings of different homotopy degree, and this distinction—not an absence of topology—is what separates them.

Charge is a π_1 winding, and this quantizes it.

The rotor circulation is a map of a loop into the $U(1)$ phase, classified by $\pi_1(U(1)) = \mathbb{Z}$. Single-valuedness of the phase permits only integer circulation,

$$n = \frac{1}{2\pi} \oint d\varphi \in \mathbb{Z},$$

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and a would-be fractional value (e.g. $n = 2/3$) fails to close: the configuration is torn, not a field. Charge quantization is therefore *topological*—an integer winding cannot be continuously deformed to a nearby non-integer one—and this is an explanation the Standard Model does not supply, since it postulates quantization. FORCED.

The observed thirds come from the centre, not from fractional winding.

Because winding numbers are strictly integers, the fractional charges cannot be fractional twists. They arise from the centre quotient: the true gauge group is $[SU(3) \times SU(2) \times U(1)]/\mathbb{Z}_6$, and the $\mathbb{Z}_3$ centre of colour, acting on a triplet by $e^{2\pi i/3}$, is identified with a $\mathbb{Z}_3$ subgroup of the $U(1)$. Consistency then imposes a congruence on triplet hypercharges, so that

$$Q = n/3 \text{ (colour triplets),} \quad Q = n \text{ (colour singlets),} \quad n \in \mathbb{Z}.$$

The thirds are integer windings measured after the $\mathbb{Z}_3$ quotient—the centre-to-fraction law—and they agree with the $\mathbb{C} \otimes \mathbb{O}$ ladder, where $N \in \{0,1,2,3\}$ is an integer and the denominator is $N_c = 3$. FORCED.

Baryon number is a π_3 winding, and the two cannot be identified.

Baryon number is the degree of a map $S^3 \rightarrow SU(2)$, $\pi_3(SU(2)) = \mathbb{Z}$, measured by the Maurer–Cartan density $B = 1/24\pi^2 \int \epsilon^{ijk} \text{Tr}(L_i L_j L_k)$ —a three-form invariant, whereas the circulation integral above is a one-form invariant. The obstruction between them runs both ways. $\pi_3(U(1)) = 0$: the abelian winding density vanishes identically on any abelian map (verified $\sim 10^{-16}$), so the charge $U(1)$ cannot generate B . Conversely $\pi_1(SU(2)) = 0$, since $SU(2) = S^3$ is simply connected, so a Skyrme configuration carries no loop winding and cannot carry electric charge. Every octonionic ideal or projective target is likewise π_3 -trivial, $\pi_3(\mathbb{O}P^1 = S^8) = \pi_3(\mathbb{O}P^2) = \pi_3(\mathbb{C}P^7) = \pi_3(S^{15}) = 0$, so no “ideal-valued field winds to give N ” construction has a target; and where $\pi_3 = \mathbb{Z}$ does occur (in $SU(3), G_2, F_4$), Bott’s theorem makes its generator an $SU(2)$ subgroup—the same quaternionic S^3 the soliton already uses. The two integers are therefore of different homotopy degree and are related only by the axial anomaly, through which fermion number flows into winding with coefficient N_c : a relation of *values*, not an identity of currents. NEGATIVE for the identification; the labeling $Y_{\text{alg}} = B_{\text{top}}$ is INPUT.

A chiral generation is not hosted by $\mathfrak{F}_3(\mathbb{O})$ alone

Breaking $F_4 \supset SU(3)_c \times SU(3)_{ew} \supset SU(3)_c \times SU(2)_L \times U(1)_Y$ fixes the hypercharge ratios (Sec. 6.2), a genuine gain over $\mathbb{C} \otimes \mathbb{H}$ alone. But the **26** of F_4 is a *real* representation: its hypercharge spectrum is exactly symmetric under $Y \rightarrow -Y$ (verified over all 26 states), delivering a generation *and its mirror*, with $\sum Y = \sum Y^3 = 0$ the trivial trace identities of a self-conjugate rep rather than the nontrivial chiral anomaly conditions. Extracting one chiral generation requires a hand projection breaking the algebra’s structure. Chirality’s *existence* (the $\mathbb{Z}_2$ grading) is FORCED; a chiral generation from $\mathfrak{F}_3(\mathbb{O})$ alone is NEGATIVE. The minimal enlargement recovering chirality is E_6 , whose **27** is complex.

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Complexification: from impossible to representable.

The obstruction is dissolved not by hand-projecting inside F_4 but by complexifying the algebra. The vortex circulation supplies a physical complex structure—the 90° phase between divergence (charge) and curl (spin) in $C = Q - i\Gamma$ —so promoting $\mathfrak{J}_3(\mathbb{O})$ to $\mathfrak{J}_3(\mathbb{O}) \otimes \mathbb{C}$ is algebraically natural rather than ad hoc. Its structure group is E_6 rather than F_4 , and E_6 possesses *complex* representations: the fundamental **27** is complex and is exactly one chiral generation, including a right-handed neutrino. This retires the absolute obstruction—in F_4 a chiral generation is *impossible* (real reps only); in E_6 it is *representable* (the complex **27**). What remains is not an impossibility but a choice: E_6 contains both **27** and $\overline{\mathbf{27}}$ (CPT-conjugates) and permits either a chiral filling (**27**_L alone) or a vectorlike one (**27**_L $\oplus$ **27**_R); it does not force the former. Parity violation therefore upgrades from NEGATIVE (impossible in F_4) to a single discrete INPUT—the choice to fill **27**_L—unified via *CPT* (Sec. 8.4) with the one CP-phase input. We do *not* claim the fluid complex structure orients this choice: the i in $C = Q - i\Gamma$ relates the *spatial* divergence and curl, whereas the chiral orientation is set by the *Lorentz* γ^5 , and identifying a spatial phase with the spacetime volume element is not established. The gain is bounded and precise: chirality goes from *impossible* to *possible*, and its orientation becomes the same single input as CP.

The QCD scale and the Yukawa sector

The baryon mass separates into a small quark-mass piece ($\sim 1\%$, Yukawa INPUT) and a large binding piece ($\sim 99\%$) equal to $c_0 \Lambda_{\text{QCD}}$ with $\Lambda_{\text{QCD}} = \mu_0 \exp[-2\pi/(b_0 \alpha_s(\mu_0))]$. The geometry forces the structure: $N_c = 3$, the sign and value $b_0 = 11 - 2/3 n_f$ (the +11 gluon self-coupling producing confinement), the existence of a scale, and that mass is $\sim 99\%$ binding. It does not force the scale; α_s at one scale is the single irreducible number, appearing as (F_π, e) in the soliton language. Masses beyond the down-lepton Clebsch $N_c = 3$, mixing angles, and CP phases live in the Yukawa sector, on which the representation theory is silent; the Georgi-Jarlskog pattern and the Koide relation are empirically suggestive but not forced. INPUT; the SM does not derive these either.

The mass spectrum: forced form, unforced number.

With particle/antiparticle symmetry ($\lambda \leftrightarrow -\lambda$) the generation mass sextic collapses to an even polynomial and, under $m^2 = \lambda^2$, to a cubic resolvent $(m^2)^3 + c_2(m^2)^2 + c_4(m^2) + c_6 = 0$ with Vieta coefficients $-c_2 = \sum m_i^2$, $c_4 = \sum_{i < j} m_i^2 m_j^2$, $-c_6 = \prod m_i^2$. This is correct as *structure* but carries no predictive content alone: the map $(m_1, m_2, m_3) \leftrightarrow (c_2, c_4, c_6)$ is a bijection, so three coefficients fit three masses for any spectrum, and the block matrix carries 36 free parameters feeding those three. A prediction requires fixing the coefficients with *fewer* than three degrees of freedom. Three-fold symmetry supplies part of that reduction, and the resulting structure—together with what is and is not forced within it—is developed in full in Sec. 10.

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The Charged-Lepton Mass Structure: Three Notes of One Rotor

The three charged-lepton masses are not independent. Writing the square-root masses $z_k = \sqrt{m_k}$ and decomposing them into a democratic mean plus a circulant deviation,

$$z_k = a + b \cos(\theta + 2\pi k/3), \quad k = 0, 1, 2,$$

reproduces the electron, muon, and tau exactly with a single scale a , a single amplitude b , and a single phase θ . In this form the three leptons are three *notes* of one rotor: the same a and b , with phases separated by 120° . This is the period-three closure of a rotation on the circle—the three-spoke standing wave—and it is the reason the generation count is three rather than any other number. The form is not an ansatz: by Sec. 5.1 it is the Viète trigonometric solution of the cubic the Freudenthal cubic, so the circulant decomposition is the spectral form of the Freudenthal invariant itself. FORCED.

The Koide relation and its single free amplitude

Under this decomposition the Koide quantity depends only on the amplitude ratio b/a :

$$Q = \frac{\sum_k z_k^2}{(\sum_k z_k)^2} = \frac{1}{3} \left(1 + \frac{b^2}{2a^2} \right).$$

The charged leptons sit at $b/a = 1.41420 \simeq \sqrt{2}$, giving $Q = 0.666661 \simeq 2/3$ to five significant figures. The three-fold structure therefore makes Q a *one-parameter* quantity—a genuine reduction from three independent masses to a single amplitude—and this reduction is FORCED. What is not forced is the *value* of that amplitude: $Q = 2/3$ requires exactly $b^2/a^2 = 2$, equivalently that the square-root-mass vector lie at 45° to the democratic diagonal (1,1,1).

The amplitude is an input, on present evidence

We tested whether $b^2/a^2 = 2$ is compelled by the geometry, through several independent structural routes:

1. the two-dimensional rotor plane ($U(1)$) as a mode count—requires an unproven equipartition and, under the length-preserving relation $J^2 = -1$, forces $b^2/a^2 = 1$ ($Q = 1/2$), not 2;
2. the double cover (720°)—enters as a frequency, which cancels in the time-averaged intensity and does not appear in b^2/a^2 ;
3. cube geometry in three-dimensional mass space—the cube edge splits perpendicular to parallel as 2: 1 exactly, but at 54.7° (the edge, $Q = 1$), not at the 45° of the lepton state, so it is a different 2;

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4. the invariant ratio I_2/I_1^2 of $\mathfrak{S}_3(\mathbb{O})$ —Koide sits at the midpoint $1/6$ between the rank-one idempotent (0) and the identity (1/3), the “half-rank” point, which is suggestive but not a distinguished element of the algebra;
5. a circle map $\alpha = \arctan(\sqrt{|x^2 + a|}/x)$ whose three-spoke lock occurs at input $a = 2x^2$, re-encoding the same factor 2 rather than deriving it.

Each route reproduces the value only by admitting the factor 2 as an input. The consistent outcome is that the three-fold *form* is forced while the amplitude $\sqrt{2}$ is not: on present evidence $b/a = \sqrt{2}$ is an INPUT, of the same character as the free Yukawa couplings of the Standard Model, and consistent with Q being renormalization-group marginal (preserved to $\sim 10^{-5}$ across scales) rather than an attractor.

Why the relation is a colour-singlet fact

The relation is specific to the charged leptons, and this is a consequence of confinement rather than an accident of fitting. The Koide quantity requires fixed, physical masses. Charged-lepton pole masses are physical and scale-independent, so b^2/a^2 has a definite value. Quark masses are confined, scheme- and scale-dependent: the corresponding ratio for the up-type sector moves from 3.09 near 2 GeV to 3.33 near M_Z . A fixed structural relation cannot equal a scale-dependent target, so no Koide-type identity can hold cleanly for quarks. Attempts to convert the lepton result into a quark prediction by a degrees-of-freedom correction fail for the same reason and for two further ones: colour ($N_c = 3$) is identical for up- and down-type and cannot produce their difference, and requiring the correction to preserve the lepton value forces its charge/isospin part to vanish. Only the colour-singlet sector possesses the fixed physical masses a mass relation requires, so Koide is necessarily a lepton-sector phenomenon. This is a FORCED explanation of the relation’s selectivity, not a shortcoming of the mechanism.

Statement	Status
Three leptons as circulant notes of one rotor	FORCED
Circulant form = Viète solution of the Freudenthal cubic	FORCED
Q a single-parameter quantity	FORCED
Charged-lepton $Q = 2/3$ to five figures	observed
Amplitude $b/a = \sqrt{2}$	INPUT (five routes, all re-encode it)
Koide holds for leptons, cannot for quarks	FORCED (running masses)

Falsifiable Consequences: The E_6 Spectrum Beyond the Standard Model

The complexification $\mathfrak{F}_3(\mathbb{O}) \rightarrow \mathfrak{F}_3(\mathbb{O}) \otimes \mathbb{C}$ was introduced for a structural reason—only a complex representation can host a chiral generation—but it is not free of consequences. The fundamental representation of E_6 is the **27**, and a Standard Model generation occupies only 15 of its Weyl states. The remaining 12 states per generation are therefore not optional: they are required by the same representation that supplies chirality. This is the one place where the construction makes predictions that differ from the Standard Model rather than reproducing it.

Decomposition of the **27**

Under $E_6 \supset SO(10) \times U(1)_\psi$ the fundamental decomposes as $\mathbf{27} = \mathbf{16} \oplus \mathbf{10} \oplus \mathbf{1}$, where the **16** is one chiral generation together with a right-handed neutrino and the $\mathbf{10} \oplus \mathbf{1}$ are additional, vector-like states. The table below lists the content in Standard Model labels, with the hypercharge written as the net source/sink flux $3Y$ of the flux-count construction.

Block	State	colour	weak	Y	flux $3Y$	states
16	$Q_L = (u, d)_L$	3	2	1/3	+1	6
16	u_R^c	3	1	-4/3	-4	3
16	d_R^c	3	1	2/3	+2	3
16	$L_L = (\nu, e)_L$	1	2	-1	-3	2
16	e_R^c	1	1	2	+6	1
16	ν_R^c	1	1	0	0	1
10	D (exotic quark)	3	1	-2/3	-2	3
10	$\bar{D}$ (exotic quark)	$\bar{3}$	1	2/3	+2	3
10	H_u (extra doublet)	1	2	1	+3	2
10	H_d (extra doublet)	1	2	-1	-3	2
1	N (singlet)	1	1	0	0	1
total						27

The flux-count structure extends to the full **27**

The decomposition passes three nontrivial checks in the language of the flux-count construction, none of which was imposed.

1. *Integrality.* Every hypercharge in the **27** is an integer multiple of $1/3$; the fluxes are $\{-4, -3, -2, 0, +1, +2, +3, +6\}$, all integers. The $1/3$ quantum established for one generation therefore governs the exotic states as well.

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2. *Anomaly traces.* Both $\sum Y$ and $\sum Y^3$ vanish over the full **27**, and separately over the chiral **16** alone. (E_6 is anomaly-free, so the first is expected; the second is the Standard Model generation condition recovered inside it.)
3. *Chirality read as flux balance.* The chiral **16** carries nonzero individual fluxes, whereas the exotic $\mathbf{10} \oplus \mathbf{1}$ has fluxes that cancel in pairs ($D/\bar{D}$ at ∓ 2 , H_u/H_d at ± 3 , N at 0). Vector-like content is thus precisely source/sink-balanced content, and chirality is flux imbalance—the flux-count picture reproduces the chiral/vector-like distinction without being told about it.

These are consistency results rather than new predictions, but they show the construction survives extension from 15 to 27 states. FORCED.

What is predicted, and how it can fail

Beyond a Standard Model generation the **27** requires, per generation: a **right-handed neutrino** ν_R (colour and weak singlet, $Y = 0$), enabling a seesaw mass mechanism and testable indirectly through neutrinoless double beta decay, cosmological N_{eff} , and the light-neutrino mass scale; an **exotic quark** D with its conjugate, a colour triplet of electric charge $-1/3$ that is a *weak singlet*—the most distinctive signature, and not a fourth generation, since a sequential fourth-generation quark would be a weak *doublet* whereas the D is vector-like and isosinglet, with different production and decay phenomenology; **extra Higgs-like doublets** H_u, H_d with fluxes ± 3 ; and a **Standard Model singlet** N . In addition $\text{rank} E_6 = 6$ while $\text{rank}(SU(3) \times SU(2) \times U(1)) = 4$, so up to two additional $U(1)$ factors survive, implying one or more extra neutral gauge bosons (Z').

The construction is falsified if the chiral generation is shown to require no complexification, or if the exotic sector is excluded at all accessible scales. At present none of these states is excluded: collider limits stand near 4–5 TeV for an E_6 Z' and near 1.2–1.5 TeV for vector-like isosinglet quarks.

Baryon-number violation: a prediction and an unresolved constraint

The same feature that makes the **27** attractive—quarks and leptons in one irreducible multiplet—necessarily breaks the accidental baryon-number conservation of the Standard Model.

Prediction.

In the Standard Model, baryon number is conserved accidentally: no renormalisable gauge-invariant operator violates it. The proton is therefore stable despite a large available phase space, the decay $p \rightarrow e^+ \pi^0$ releasing 803 MeV. Any framework placing quarks and leptons in a common multiplet removes that accident and requires proton decay at some rate—a falsifiable difference from the Standard Model, currently bounded by $\tau(p \rightarrow e^+ \pi^0) > 2.4 \times 10^{34}$ yr.

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Constraint.

The exotic D admits two classes of gauge-invariant Yukawa coupling, the diquark $\bar{D} u^c d^c$ and the leptoquark $\bar{D} Q_L L_L$, and *both* conserve colour, weak isospin, and hypercharge; the flux-count structure assigns each a vanishing total flux and therefore forbids neither. If both are unsuppressed, tree-level D exchange gives $\Gamma \sim \lambda^4 m_p^5 / M_D^4$, a proton lifetime of order 10^{-20} yr for $M_D \sim 1$ TeV and $\lambda \sim 1$ —some 55 orders of magnitude below the bound. One coupling class must therefore be strongly suppressed.

What does not resolve it.

Three natural candidates fail. *Flux conservation*: since $\text{flux} \equiv 3Y$ exactly, it is hypercharge conservation and supplies no additional rule. $B - L$: both couplings require the identical charge $(B - L)_{\bar{D}} = 2/3$, and the standard mode $p \rightarrow e^+ \pi^0$ has $\Delta B = \Delta L = -1$ and hence *conserves* $B - L$, so no $B - L$ quantum number of any origin can forbid it. *Topological stability*: the topological baryon number of Sec. 7 is the winding of the *pion* field, defined in the low-energy effective theory, whereas the dangerous process occurs at the scale M_D where quarks rather than pions are the degrees of freedom; the Wess–Zumino term links the topological and quark-level baryon numbers with coefficient N_c , so violation of one implies violation of the other; a topological invariant constrains field configurations but cannot remove a gauge-invariant operator from the Lagrangian; and the barrier is not infinite, since electroweak sphalerons already change the winding number at finite energy $E_{\text{sph}} \sim 4\pi v/g$.

No abelian factor within E_6 supplies the rule.

Since $\text{rank} E_6 = 6$ against rank 4, two spare abelian factors survive, and it is natural to seek the rule among them. They do not provide one. Along $E_6 \supset SO(10) \times U(1)_\psi \supset SU(5) \times U(1)_\chi \times U(1)_\psi$, with $\mathbf{27} = \mathbf{16}(1) + \mathbf{10}(-2) + \mathbf{1}(4)$, $\mathbf{16} = \mathbf{10}(-1) + \bar{\mathbf{5}}(3) + \mathbf{1}(-5)$ and $\mathbf{10} = \mathbf{5}(2) + \bar{\mathbf{5}}(-2)$, both couplings carry $\sum \chi = \sum \psi = 0$, and hence so does every combination $U(1)_\theta = \cos \theta U(1)_\chi + \sin \theta U(1)_\psi$. The same holds for the effective operator $(u^c d^c)^\dagger (Q_L L_L)$ obtained by integrating out the D , so no Gauss-law argument protects the proton either: initial and final states carry identical $U(1)'$ charge. The reason is structural. The E_6 Yukawa invariant is the cubic $\mathbf{27} \times \mathbf{27} \times \mathbf{27}$ —the Freudenthal determinant—and its $\mathbf{16} \times \mathbf{16} \times \mathbf{10}$ part yields the ordinary Yukawa couplings together with *both* $Q_L L_L \bar{D}$ and $u^c d^c \bar{D}$. The two operators are components of a single E_6 invariant, so no subgroup of E_6 distinguishes them. NEGATIVE.

What is required.

Control of the exotic sector therefore demands a symmetry *external* to E_6 : an imposed discrete parity under which D is odd, or exotics heavy enough ($M_D \gtrsim 3 \times 10^{16}$ GeV) that the rate is suppressed by mass alone—at the cost of any collider signature—or couplings set small by hand. Each is an assumption. We record it as an open requirement: the construction determines the hypercharge assignment but not the additional structure needed to control the exotic sector. INPUT.

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Honest scope of the claim

Two limitations must be stated plainly. First, this spectrum is a standard consequence of E_6 unification and is not original here; what is original is the route by which E_6 is reached (complexification forced by the requirement of a chiral generation) and the observation that the flux-count structure extends consistently over the whole **27**. Second, group theory fixes the *content* of the spectrum but not its *scale*: the masses of ν_R , D , and Z' are set by the symmetry-breaking pattern and remain INPUT. The prediction is that these states exist, not that they exist at a specified energy—a genuine difference from the Standard Model, which contains none of them, but a weakly constrained one.

Statement	Status
27 requires 12 states per generation beyond the SM	FORCED (given the complex 27)
All 27 hypercharges are integer fluxes (1/3 quantum)	FORCED (verified)
$\sum Y = \sum Y^3 = 0$ over the 27 and over the 16	FORCED (verified)
Vector-like content = pairwise-cancelling flux	FORCED (verified)
Existence of ν_R , isosinglet D , extra doublets, Z'	predicted; <i>differs from SM</i>
Proton decay required by quark–lepton unification	predicted; <i>differs from SM</i>
Control of the exotic couplings	INPUT (external symmetry)
Masses of the exotic states	INPUT (breaking scale)
Originality of the spectrum itself	inherited from E_6

Comparison with the Standard Model

Standing relative to the SM.

Item	Standard Model	Source–sink–rotor / $\mathfrak{F}_3(\mathbb{O})$
$SU(3)$, charge in thirds, $N_c = 3$	input	FORCED
Hypercharge pattern of a generation	input (assigned)	FORCED (flux-count ratios)
Confinement mechanism, b_0 sign	input	FORCED (structure)
Spin-1/2, Fermi statistics	input	FORCED
Skyrme stabilizer form	ansatz	FORCED (strain e_2)
CP-violation structure (triangle area)	input phase δ	FORCED (Bargmann); generic
QCD scale, Yukawas, mixing magnitudes	input	INPUT— <i>tie</i>
Parity orientation	input	INPUT— <i>tie</i>
A working chiral generation	implements it	NEGATIVE in F_4 ; representable in E_6

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The construction *derives* several facts the SM posits ($N_c = 3$, charge quantization, the hypercharge pattern, the confinement mechanism, spin statistics, the soliton stabilizer, and the structural form of CP violation); it *ties* the SM on every free parameter and on parity orientation, where “geometry cannot force it” carries no penalty because the SM cannot either; and it falls one provable step *behind* in exactly one place, chiral representation content, which E_6 would recover.

Conclusion

From a single premise—a source, a sink, and the rotor between them—together with the division-algebra tower and its exceptional Jordan closure, a substantial and parameter-free block of the Standard Model’s discrete structure follows: the gauge group and color count, the electric-charge spectrum, the full hypercharge pattern of a generation as a rigid flux-count, spin-1/2, one generation, the nucleon as a soliton with a derived stabilizer, and the structural origin of CP violation as a geometric triangle area. Two integers organize the whole picture: $N_c = 3$, which appears as the color count, the charge sum, both anomaly traces, and the fermion-statistics sign; and the quaternionic $SU(2)$, which supplies every π_3 winding, including those inside the octonionic groups. What the geometry does not reach—the QCD scale, the Yukawa sector, the orientation of parity—it fails to reach for reasons we state precisely, and in each case the Standard Model fails identically. The claim is not that geometry is the complete origin of the Standard Model, but that it is the demonstrable origin of its discrete skeleton, with a boundary that is itself a theorem.

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