

Article 5: W-Axis Synthesis

Dimensional Momentum and the Unified Planck Scale

*Revised against the τ -loop architecture (Article 1b), the atomic model (Article 4)
and the monopole construction (Article 7)*

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Abstract

This article develops the W-axis as the phase domain of the τ -loop (Article 1b) and uses it to connect the mass domain (Q^2) and the charge domain (Q^3) through the square root of Planck momentum, Q . The identity $Q^2 \times Q^3 = Q^5$ is the momentum form of $\Omega^2 \times \Omega^3 = \Omega^5$, which identifies the monopole blocks $D = AL$ and $U = AV$ of Article 7 as Ω^5 objects. From these blocks we build the electron (DDD), the positron (DUU) and a photon primitive $\gamma = DDU$. The photon primitive is the unique three-block composite that needs no power of the time unit T to be scalar-free, and it is therefore neutral and massless. Electron–positron annihilation to two photons conserves the monopole blocks, the charge and the power of T . The orbital period per unit radius carries the scale $r_\alpha = \sqrt{2/\alpha}$ twice in the atomic regime and once in the gravitational regime, and the extra factor is traced to the atomic rotation law of Article 4. The Ampere is identified as the carrier of the charge-domain amplitude Ω^3 from which the blocks are completed. Thought experiments — a three-wave model of the vacuum and a coincidence-dynamics account of the shift from r_α to r_α^2 — are collected in an appendix, together with the assumptions on which each depends.

1 The Planck momentum Q

The geometrical square root of momentum $P = \Omega r^2$ is the bridging object of this model. Evaluated with the SI scalar r , it is the square root of the model’s Planck momentum, which we write Q (Article 6):

$$\Omega = \sqrt{\pi^e e^{1-e}} = 2.007134954\dots, \quad r = 0.712\,562\,514\,304\dots \text{ (kg m/s)}^{1/4}, \quad (1)$$

$$Q = \Omega r^2 = \sqrt{\frac{m_P c}{2\pi}} \approx 1.019113413 \text{ (kg m/s)}^{1/2}. \quad (2)$$

The second equality holds identically for the model's Planck mass, $m_P = 2\pi Q^2/c = 2.1767282 \times 10^{-8} \text{ kg}$. A reader substituting the CODATA value of m_P instead obtains a Q some 68 ppm lower; the difference belongs to the determination of m_P (Article 6), not to (2).

The Q-bridge. The mass domain is carried by Q^2 and the charge domain by Q^3 , and their product

$$Q^2 \times Q^3 = Q^5 \quad (3)$$

is the node at which the two domains meet. In the geometric language of Articles 1b and 7 the same statement reads

$$\Omega^2 \times \Omega^3 = \Omega^5, \quad (4)$$

because the kinematic objects scale as Ω^2 (the velocity $V = 2\pi\Omega^2 v$ and the length $L = 2\pi^2\Omega^2 r^9/v^5$) while the electromagnetic amplitude scales as Ω^3 (the Ampere, Section 8). The Ω^5 object is the monopole block of Section 5: a block is the product of kinematic depth and electromagnetic content.

2 The W-axis as the phase domain of the τ -loop

Definition 1 (W-axis). *The W-axis is the phase domain of a τ -loop: the direction, orthogonal to the real coordinate axis, in which the loop's phase advances while its amplitude runs from Ω to Ω^2 .*

As established in Article 1b [4], the evaluation between integer events sweeps the amplitude $A(\tau) = \Omega^{\ln \tau + 1}$ for $\tau \in [1, e]$, and the phase advances by π before the loop closes on $\Psi(e) = -\Omega^2$. The W-axis is the domain of that phase. It is not an additional postulate: it is the interior of the discrete step.

Every τ -loop has a W-axis, and the loops of this model differ only in how many ticks one loop spans:

- the Planck scaffolding completes one loop per Planck tick;
- a bound atom completes one loop per simulation step, so that the orbital step and the atom's internal clock are one clock (Article 1b);
- a photon is a loop that never closes (Section 6).

When the winding of the W-axis is counted during an atomic transition, it is the atom's winding that is counted; the photon does not enter it (Article 1b). A photon's propagation at speed c is spatial — lateral motion on the hypersphere surface — and should not be confused with advance along the W-axis, which is a phase.

The $\sqrt{\text{integer}}$ character of the W-axis follows from the Theodorus phase accumulation $\Theta_n \approx 2\sqrt{n}$ (Article 1b), which forces radiation and temperature to scale differently from spatial mass.

3 The scale r_α

We define

$$r_\alpha = \sqrt{\frac{2}{\alpha}} = 16.5551198\dots, \quad r_\alpha^2 = \frac{2}{\alpha} = 274.071992\dots, \quad (5)$$

evaluated with the series reference value (Article 4)

$$\alpha_{inv} = \sqrt{(471964 + \frac{1}{3})/8\pi} = 137.03599583.$$

The square $r_\alpha^2 = 2\alpha^{-1}$ is the ground-state orbital radius r_0 of the atomic model in units of ℓ_0 , and the orbital period in steps is then

$$T_1 = 2\pi r_0^2 = 2\pi r_\alpha^4 = 8\pi\alpha^{-2} = 471964.333\dots \quad (6)$$

This is an identity, not a derivation: it restates the definition of T_1 in terms of r_α . An interpretation of r_α^4 as the product of two domain cycles is given in Appendix A.5.

A note on notation. Article 3 uses the symbol r_α for the quantity $2/\alpha$, which is r_α^2 in the notation of this article and of Article 4; its orbital formulas are consistent only with that reading. The two articles should be read with this in mind, and a common symbol adopted in a future revision.

4 The orbital period in two regimes

Both the gravitational and the atomic models advance an orbiting point by an angle proportional to $r^{-3/2}$ per update, and their orbital periods take the form $T = 2\pi C r^{3/2}$, where C is the effective constant of the period. The period per unit radius is then

$$\frac{T}{r} = 2\pi C \sqrt{r}. \quad (7)$$

Atomic regime (Article 4). The period constant is $C = r_\alpha$, the constant of Article 4's rotation law, and the ground-state radius is $r_0 = r_\alpha^2$, so $\sqrt{r_0} = r_\alpha$ and

$$\left. \frac{T}{r} \right|_{\text{atom}} = 2\pi r_\alpha^2. \quad (8)$$

Gravitational regime (Article 3). Article 3 reports the period

$$t = 2\pi\mu \frac{r}{v} = 2\pi\sqrt{i/j} r^{3/2},$$

whose effective constant $\sqrt{i/j}$ tends to 1 as the central mass grows. (Article 3's per-pair rotation constant is $\sqrt{2j/i}$, tending to $\sqrt{2}$; the period constant differs from it because the orbit is traced about the barycenter.) The orbital radius at minimum k_r tends to $2r_\alpha^2$, so that $\sqrt{r} \rightarrow \sqrt{2}r_\alpha$ and

$$\left. \frac{T}{r} \right|_{\text{grav}} \rightarrow 2\pi\sqrt{2}r_\alpha. \quad (9)$$

Evaluating Article 3's own formulas gives $2\pi\sqrt{2}r_\alpha$ to within 0.05% for $i = 10^3$ and exactly in the limit, the excess being $\sqrt{(i+1)/i} - 1$.

The source of the extra factor. In both regimes the orbital radius scales as r_α^2 and contributes one factor $\sqrt{r} \propto r_\alpha$. The atomic period carries a *second* factor, r_α , as its constant, where the gravitational period's constant tends to 1. The shift from r_α to r_α^2 is therefore located precisely: it is the atomic rotation constant. It arises at every step and deterministically.

Why the atomic rotation constant should be r_α is not derived here or in Article 4, where it is introduced in place of the gravitational constant. Appendix A records two thought experiments that offer an interpretation — a three-wave vacuum and a coincidence-dynamics model — together with the assumptions on which they rest.

5 The monopole blocks

Following Article 7 [9], define the two monopole blocks

$$D \equiv AL, \quad U \equiv AV, \quad (10)$$

each an Ω^5 object by (4), with unit numbers

$$\theta(D) = \theta(A) + \theta(L) = 3 - 13 = -10, \quad \theta(U) = \theta(A) + \theta(V) = 3 + 17 = +20, \quad (11)$$

translation scalars $D \sim r^3 v^{-2}$ and $U \sim r^{-6} v^4$, and fractional charges $-\frac{1}{3}e$ and $+\frac{2}{3}e$.

Charge equals the power of T . With $T \sim r^9 v^{-6}$, each block's scalar content is exactly minus its charge times T :

$$\text{scalars}(q) = -Q_{\text{ch}}(q) \times T. \quad (12)$$

Scalars add under composition, as do charges, so a composite of total charge Q_{ch} becomes scalar-free — and so describes an observable object — precisely when multiplied by $T^{Q_{\text{ch}}}$ (Article 7). Three consequences follow:

composite	charge	power of T	
D, U , and all pairs	fractional	fractional	confined
DDD	-1	-1	electron
DDU	0	0	photon primitive
DUU	$+1$	$+1$	positron

A composite of fractional charge would need a fractional power of T , for which no integer cancellation exists; single blocks and all pairs are therefore confined, and only triplets can be free. The electron invariant is DDD/T — the $\psi = \sigma_e^3/2T$ of Articles 1b and 7 — and the positron requires the inverse power. The sign of the power of T distinguishes matter from antimatter.

Naming. DUU here is the positron. In standard QCD the quark content uud is that of the proton, and the resemblance of the labels should not be read as an identification.

6 The photon primitive $\gamma = DDU$

Article 7 motivates a photon built from the same blocks as the electron sector:

$$\gamma \equiv DDU = (AL)^2(AV). \quad (13)$$

Its unit number is $\theta(\gamma) = 2(-10) + 20 = 0$, and its scalars cancel without any power of T : $2(3, -2) + (-6, 4) = (0, 0)$. It is the unique triplet with this property. Since T is the mass-bearing time unit, the charge-neutral composite is exactly the one that carries none of it: γ is neutral and massless.

The Ω^{15} scaling. Since D and U are each Ω^5 blocks, $\gamma \propto (\Omega^5)^3 = \Omega^{15}$. This connects the photon primitive to the render invariant $I = \pi^2(\Omega^5)^3$ of Article 1b, in which Ω^5 is the monopole quantum. It does not, however, single out the photon: DDD and DUU are also three Ω^5 blocks and also scale as Ω^{15} . What distinguishes γ is the absence of T , not the power of Ω .

The photon as a non-closing τ -loop (Article 1b). The photon is a τ -loop with no closure condition. It never reaches the Ω^2 collapse boundary, so it has no point-state, no spatial coordinate and no mass ($M = 0$), and it cannot interact with the spiral directly. It is the null case of branch differentiation. Its frequency is set by its energy, and it can oscillate indefinitely without completing a loop: a τ -loop is what terminates in a point-state, and an electromagnetic oscillation is not.

7 Electron–positron annihilation

The two-photon final state of electron–positron annihilation is a recombination of the same blocks:

$$e^- \sim DDD, \quad e^+ \sim DUU \quad \Longrightarrow \quad DDD + DUU \rightarrow DDU + DDU = \gamma + \gamma. \quad (14)$$

Three quantities are conserved together: the blocks ($4D + 2U$ on each side), the charge ($-1 + 1 = 0 + 0$), and the power of T ($-1 + 1 = 0 + 0$). The last is the statement that the mass-bearing unit carried by the electron and positron is exactly released. This is offered as a geometric accounting identity consistent with QED, not as a replacement for it; the two photons emerge with opposite propagation directions in the centre-of-mass frame.

8 The Ampere and the quintic blocks

The Ampere, the geometrical Planck unit of current, carries the charge-domain amplitude Ω^3 of (4); multiplied by a kinematic Ω^2 object it forms the quintic Ω^5 blocks of Section 5. Its value is

$$A = \frac{128\pi^3\alpha Q^3}{m_P^3} = \frac{256\pi^3 Q^3}{m_P^3 r_\alpha^2} \approx 2.9722126 \times 10^{24}, \quad (15)$$

using $\alpha = 2/r_\alpha^2$ and the model's m_P . Since $Q^3/m_P^3 = \Omega^3 v^3/r^6$, this is the object value $2^7\pi^3\alpha\Omega^3$ of the Ampere in Article 1b, as it must be. The derivation of the Ampere is given in Article 6.

An earlier version wrote $128\pi^3 Q^3/(m_P^3 r_\alpha^2)$, replacing α by $1/r_\alpha^2$ rather than $2/r_\alpha^2$; that expression evaluates to half the value quoted, which was itself correct.

9 The photon–orbital hybrid

The hybrid of Article 4 can be stated in the language of this article. A photon cannot touch the spiral, which couples only to point-states, so every photon–matter interaction routes through an object that possesses a closure condition — for a bound transition, the atom (Article 1b). The photon and the atom’s wave-state are both wave-states and can superpose; the merged state biases *where* the atom’s next point-state falls, and the radius advances by $dr = (\alpha/4\pi)\ell_0$ per step. The hybrid is not continuous: during the $1 \rightarrow 2$ transition the atom reaches a point-state some 1.4 million times, and the bias is re-applied at each.

Standing-wave closure. Requiring the hybrid to close after an integer number of windings,

$$2\pi R = n\lambda, \tag{16}$$

is the de Broglie condition, and it is equivalent to $L = n\hbar$. Article 4 shows that the model reproduces $L = n\hbar$ exactly once reduced Compton wavelengths are used, so the closure condition and the model agree. The integer n is, however, assumed rather than derived here: Article 4 shows that phase closure alone selects the rational values of n , and that the integer-step condition narrows these to integers but also excludes $n = 3$.

10 Conclusion

The W-axis is the phase domain of the τ -loop, present in every loop and distinguished between objects only by the number of ticks one loop spans. The momentum identity $Q^2 \times Q^3 = Q^5$ is the statement $\Omega^2\Omega^3 = \Omega^5$, and the Ω^5 monopole blocks build the electron, the positron and a photon primitive whose masslessness follows from needing no power of T . The contrast between the atomic and gravitational orbital periods — r_α^2 against r_α per unit radius — is located in the atomic rotation constant. Why that constant is r_α remains open, and the thought experiments of the appendix are offered as interpretations of it, not as derivations.

A Thought experiments

The main text is complete without this appendix. The thought experiments below were developed to interpret the shift from r_α to r_α^2 and the photon–

orbital exchange. They are retained as possible routes to the open question of Section 4, and each is presented with the assumption on which it depends.

A.1 r_α as a fundamental scale

One reading takes r_α , rather than α , as the fundamental constant, with r_α^2 the squared projection observed from within the mass domain. If the vacuum is pictured as a resonant cavity in which two units of wave-action are distributed over a scale R with coupling efficiency α , then $\alpha = 2/R^2$ and $R = r_\alpha$. *Assumption:* the relation $\alpha = 2/R^2$ is postulated; the step to $R = \sqrt{2/\alpha}$ rearranges the postulate and does not independently derive it.

A.2 The three-wave vacuum

Model the vacuum as an intersection of standing waves of Q . Two waves rotate about $(\pm 1, 0)$ in the plane of the mass domain and meet periodically at the origin, forming one unit of Planck momentum $2\pi Q^2$ for one unit of Planck time; a third wave rotates in the zw -plane and represents the charge domain.

Wave	Domain	Centre	Plane	Scaling
1	Mass	$(+1, 0, 0)$	xy	r_α
2	Mass	$(-1, 0, 0)$	xy	r_α
3	Charge	$(0, 0, 0)$	zw	r_α

On this picture the charge domain advances only when the third wave also reaches the origin, which is proposed as the origin of the extra factor r_α .

A.3 Coincidence dynamics

Represent each wave by a phase $\phi_i(t) = \omega_i t + \phi_{i,0} \pmod{2\pi}$, $i \in \{1, 2, w\}$, and call a meeting any time at which $|\text{wrap}(\phi_i)| < \varepsilon$. Let E_{mass} be the joint meeting of waves 1 and 2 and E_w the meeting of wave w , and assume:

(H1) $\mathbb{P}(E_{\text{mass}}) \approx 1/r_\alpha$ per update;

(H2) $\mathbb{P}(E_w) \approx 1/r_\alpha$ per update;

(H3) E_{mass} and E_w are independent.

Then the waiting times to a planar and to a triple meeting are geometric, with $\mathbb{E}[W_2] \approx r_\alpha$ and $\mathbb{E}[W_3] \approx r_\alpha^2$, reproducing the two regimes.

Assumptions. (H1) and (H2) are calibrations: the rate $1/r_\alpha$ is put in rather than derived. (H3) carries the result, and it is delicate in a deterministic simulation. The τ -loop of Article 1b is deterministic, and for deterministic rotations the joint rate equals the product of the separate rates only if the two frequencies are rationally independent. If they are equal, as the symmetry of (H2) suggests, the rotations are phase-locked: the joint rate is then the single rate $1/r_\alpha$ when the waves are in phase, and zero when they are not, and never $1/r_\alpha^2$. A direct numerical check confirms all three cases. The coincidence account therefore requires the planar and W-axis frequencies to be rationally independent, which is not established. The deterministic rotation law of Section 4 produces the same factor r_α^2 without this assumption.

The τ -loop as timing. In the coincidence picture the τ -loop boundary at $\tau = e$ supplies the timing — the lattice can collapse only when the loop closes on $-\Omega^2$ — while the geometry of the waves decides which coincidences occur at that moment. On this reading the probabilities above would be long-run averages of a deterministic process, which is exactly the situation in which (H3) needs the independence condition just stated.

A.4 Absorption as a coincidence-gated update

On the coincidence picture a transition step would require both a planar meeting, to advance the orbital degree of freedom, and a W-axis meeting, to admit the photon's contribution into the orbital constraint. The photon then carries a wave-state momentum packet at the Q^2 level while the bound orbital is a Q^3 -enabled configuration, and absorption is the conversion $(Q^2)_{\text{photon}} \leftrightarrow (Q^3)_{\text{orbital}}$ across the W-axis. *Assumption:* this inherits (H1)–(H3), and it describes a stochastic gating that differs from the deterministic one-loop-per-step transition of Article 1b and Section 9.

A.5 The step count as a product of two domains

The identity $T_1 = 2\pi r_\alpha^4$ of (6) invites the reading that $r_\alpha^4 = (r_\alpha^2)_{\text{mass}} \times (r_\alpha^2)_{\text{charge}}$, the product of a mass-domain cycle and a charge-domain synchronisation cycle, so that the step count is the area of the dual-domain interaction. *Assumption:* this interprets an identity that holds by the definition of T_1 ; it adds a picture, not a derivation.

A.6 Photon and orbit as one object under different constraints

A free photon may be read as a propagating γ excitation, and an “orbital photon” as the same excitation held by a closed, helical boundary condition imposed by the local charged geometry. The difference between radiation and orbit would then be a change in the allowed trajectories of one object, not a change of its primitives, which preserves low description length. *Assumption:* the boundary condition that converts a free γ into a bound one is not specified.

A.7 The photon as a field perturbation

In the language of a normalised spinor field $\xi(x) \in \mathbb{C}^2$, one may define a $U(1)$ potential $a_\mu = -i\xi^\dagger \partial_\mu \xi$ and curvature $F_{\mu\nu} = \partial_\mu a_\nu - \partial_\nu a_\mu$, and describe a photon as a perturbation obeying the source-free equation $\partial^\nu \delta F_{\mu\nu} = 0$ on the hypersphere surface. *Assumption:* this requires a spatially varying spinor field. The three-phase construction of Article 7 does not furnish one — it yields a single state-visible degree of freedom, not a general spinor — and the field $\xi(x)$ is not specified here. The equation itself is Maxwell’s, and the construction describes the photon in standard form rather than deriving it from the τ -loop.

References

- [1] Macleod, Malcolm J. “*The Programmer God, are we in a simulation?*” <http://codingthecosmos.com>
- [2] Macleod, Malcolm J., *Programming Planck units from a virtual electron; a Simulation Hypothesis*, Eur. Phys. J. Plus (2018) 133: 278
- [3] Macleod, Malcolm J., *1. Planck unit scaffolding to Cosmic Microwave Background correlation*, <https://www.doi.org/10.2139/ssrn.3333513>
- [4] Macleod, Malcolm J., *1b. The Minimal Complexity Algorithm of the Planck Scaffolding*, <https://www.doi.org/10.13140/RG.2.2.12830.09283/1>
- [5] Macleod, Malcolm J., *2. Relativity as the mathematics of perspective in a hyper-sphere universe*, <https://www.doi.org/10.2139/ssrn.3334282>

- [6] Macleod, Malcolm J., *3. Gravitational orbits from n-body rotating particle-particle orbital pairs*, <https://www.doi.org/10.2139/ssrn.3444571>
- [7] Macleod, Malcolm J., *4. Geometrical origins of quantization in H atom electron transitions*, <https://www.doi.org/10.2139/ssrn.3703266>
- [8] Macleod, Malcolm J., *6. Natural Planck units MTP and the Fine Structure Constant*
- [9] Macleod, Malcolm J., *7. Geometric Origin of Quarks, the Mathematical Electron extended*, <https://www.doi.org/10.13140/RG.2.2.21695.16808/2>