Light, Matter, and the Place of Propagation

IPI internal correspondence note.
From conversations with:

Peter M Austin[1], John Nicholson, Iain Franklin, Isaid Rodriguez

May 2026

Abstract

This note explains how high-energy light can become matter without suggesting that ordinary light simply turns solid. It begins with the Maxwell layer: classical light as propagating electromagnetic field structure, with energy storage, energy transport, vacuum speed, and impedance. The photon then appears as the quantised excitation of that electromagnetic transport channel.

In mainstream physics, photons can produce massive particle–antiparticle pairs only when energy, momentum, charge and the relevant quantum numbers are conserved. A lone photon in empty space cannot become an electron–positron pair by itself, but photon–photon collisions, recoil from a nearby field or nucleus, and the dense interacting conditions of the early universe can satisfy the conservation requirements.

The later sections take up John Nicholson's suggestion that photons have a different relation to time, and place it beside Traian Surtea's topological language of support, boundary, and interaction. The Zen terms *mu*, *ma*, and *basho* are kept as real conceptual supports: no-thingness, interval, and place. The result is not a new law of consciousness, but a way of reading light as the least-burdened physical case of open propagation, and matter as propagation that has found a record.

[1] Diagrams by ChatGPT

Maxwell layer: light as electromagnetic transport

Before speaking about photons, pair production, or matter-like persistence, the classical field layer should be stated clearly. In Maxwell's theory, light is not a substance travelling through space. It is a propagating electromagnetic field configuration.

In SI notation, Maxwell's equations are

$$\nabla \cdot \mathbf{E} = \frac{\rho}{\epsilon_0}, \tag{1}$$

$$\nabla \cdot \mathbf{B} = 0, \tag{2}$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}, \tag{3}$$

$$\nabla \times \mathbf{B} = \mu_0 \mathbf{J} + \mu_0 \epsilon_0 \frac{\partial \mathbf{E}}{\partial t}. \tag{4}$$

Here $\mathbf{E}$ is the electric field, $\mathbf{B}$ is the magnetic field, ρ is charge density, $\mathbf{J}$ is current density, ϵ_0 is vacuum permittivity, and μ_0 is vacuum permeability.

In empty space,

$$\rho = 0, \qquad \mathbf{J} = 0. \tag{5}$$

The equations reduce to

$$\nabla \cdot \mathbf{E} = 0, \tag{6}$$

$$\nabla \cdot \mathbf{B} = 0, \tag{7}$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}, \tag{8}$$

$$\nabla \times \mathbf{B} = \mu_0 \epsilon_0 \frac{\partial \mathbf{E}}{\partial t}. \tag{9}$$

Taking the curl of Faraday's law and using the Ampere–Maxwell law gives the electromagnetic wave equation

$$\nabla^2 \mathbf{E} - \mu_0 \epsilon_0 \frac{\partial^2 \mathbf{E}}{\partial t^2} = 0, \tag{10}$$

and similarly

$$\nabla^2 \mathbf{B} - \mu_0 \epsilon_0 \frac{\partial^2 \mathbf{B}}{\partial t^2} = 0. \tag{11}$$

These are wave equations with speed

$$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}. \tag{12}$$

This is the classical origin of the connection between light and the electromagnetic structure of the vacuum. The constants μ_0 and ϵ_0 do not make light into matter. They express the electric and magnetic bookkeeping of vacuum propagation. Together they set the propagation speed and the vacuum impedance,

$$Z_0 = \sqrt{\frac{\mu_0}{\epsilon_0}} = \mu_0 c. \tag{13}$$

Maxwell's equations already contain a storage-and-transport picture. The electromagnetic field stores energy with density

$$u = \frac{1}{2}\left(\epsilon_0 E^2 + \frac{B^2}{\mu_0}\right), \tag{14}$$

and transports energy through the Poynting vector

$$\mathbf{S} = \frac{1}{\mu_0}\mathbf{E} \times \mathbf{B}. \tag{15}$$

So classical light is electromagnetic energy in transport. It is not yet a photon in the quantum sense, but it already has the structural features needed by the later discussion: field energy, field momentum, finite propagation speed, phase, and direction of transport.

The photon appears when this electromagnetic field is quantised. A photon is a quantum excitation of the electromagnetic field with energy

$$E = \hbar\omega, \tag{16}$$

and momentum

$$p = \hbar k. \tag{17}$$

For light in vacuum,

$$E = pc. \tag{18}$$

Maxwell therefore gives the classical field structure, while quantum theory gives the discrete photon excitation. Pair production belongs one layer higher again: photon-carried energy and momentum can be converted into massive particle–antiparticle excitations only when the conservation laws can close. This is why a lone photon in empty space cannot become an electron–positron pair by itself, while two photons, or a photon interacting with a nearby field or nucleus, can do so under the right conditions.

In the Recursive Survival interpretation, Maxwell's field equations describe the classical transport channel. The photon is the quantised unit of that channel. Light-like propagation is the non-closing, lossless, norm-preserving limit; matter-like behaviour appears when energy enters a history that can localise, recur, and persist through interaction. This does not replace Maxwell, relativity, or QFT. It adds an interpretive layer: electromagnetic propagation is open transport, while matter-like concentration is survival-weighted persistence.

Light becomes matter when enough photon energy is converted into massive particles, usually as a particle–antiparticle pair. The simplest example is a high-energy gamma-ray photon producing an electron and a positron.

But there is an important catch: a single photon travelling through empty space cannot simply turn into matter by itself. Energy and momentum both have to be conserved. In practice, pair production needs either another photon or a nearby field, often the electromagnetic field of an atomic nucleus, to take up the recoil.

$$\gamma + \gamma \to e^- + e^+ \tag{19}$$

Here γ denotes a photon, e^- an electron, and e^+ a positron.

Or near a nucleus:

$$\gamma + \text{nucleus} \to e^- + e^+ + \text{nucleus} \tag{20}$$

The nucleus is not usually changed internally; it mainly helps conserve momentum.

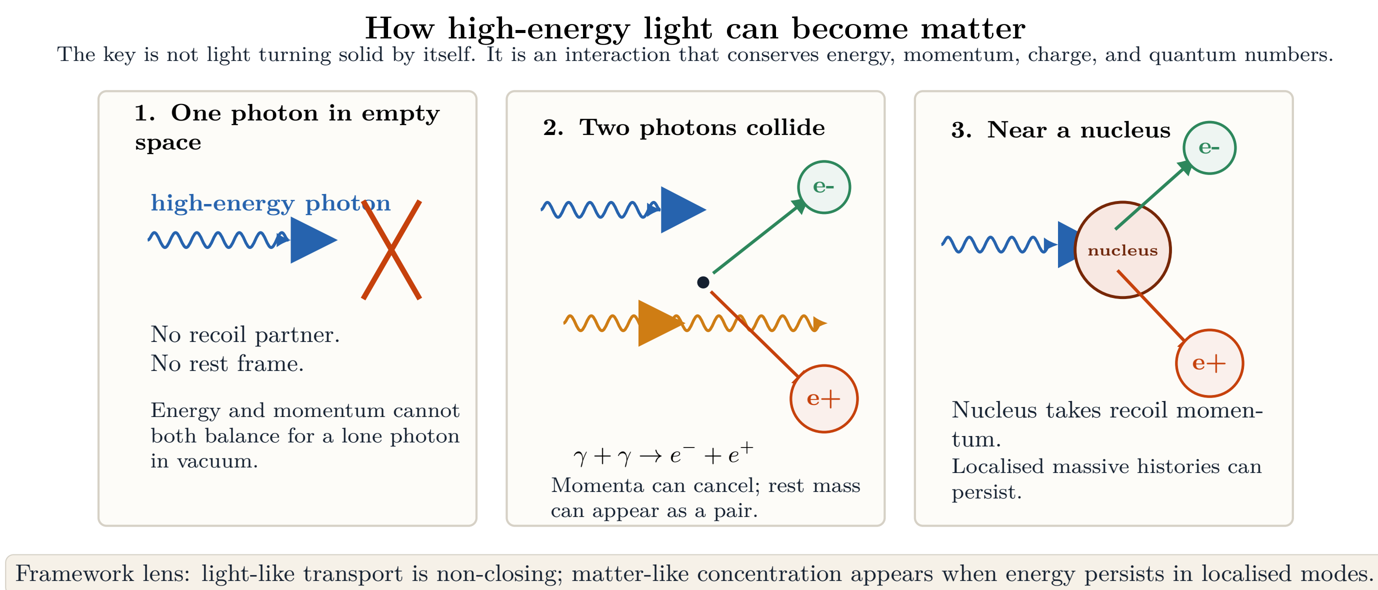

Figure 1: The basic mechanisms: a lone photon cannot become a massive pair in empty space, but photon–photon collision or recoil from a nearby nucleus can satisfy the conservation rules.

The basic idea comes from Einstein's mass–energy relation:

$$E = mc^2 \tag{21}$$

Here E is energy, m is mass, and c is the speed of light.

For an electron–positron pair, the minimum rest-energy needed is:

$$E = 2m_e c^2 = 1.022\,\text{MeV} \tag{22}$$

Here m_e is the electron mass, and MeV means million electron volts.

That is only the minimum. In real situations, extra energy is usually needed because momentum must also be balanced.

So light does not become matter in the everyday sense of a torch beam turning into a chair. Ordinary visible photons are far too low in energy. A visible photon has only a few electron volts of energy, while making even the lightest common matter pair, an electron and positron, requires over a million electron volts.

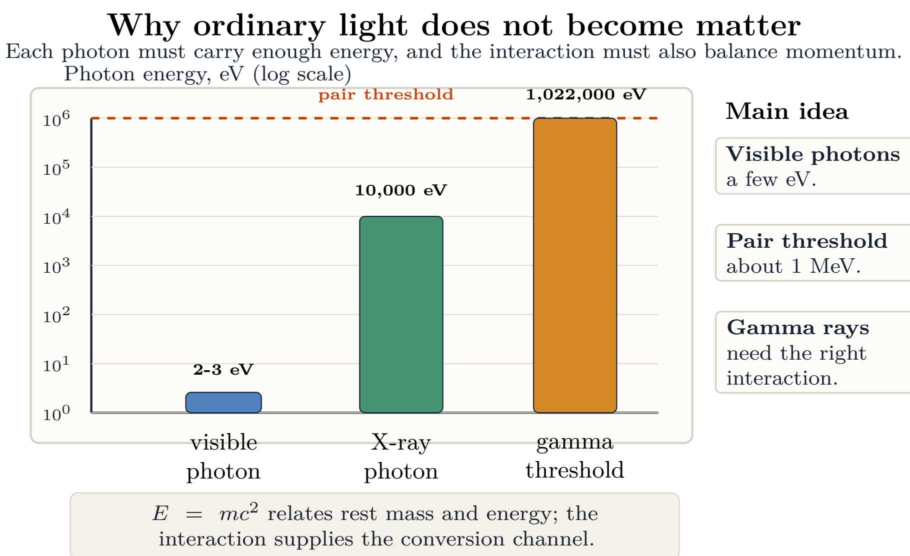

Figure 2: Visible light is many orders of magnitude below the energy scale needed for electron–positron pair production. Gamma rays can produce matter, but only in the right interaction.

More accurately, high-energy light can become massive particles when its energy is concentrated in the right interaction.

In quantum field theory, photons are excitations of the electromagnetic field. Electrons and positrons are excitations of the electron field. Pair production is not light "hardening" into stuff. It is an interaction in which energy and momentum originally carried by photons are re-expressed as excitations of massive fields.

The reverse also happens. When an electron and positron meet, they can annihilate into photons:

$$e^- + e^+ \to \gamma + \gamma \tag{23}$$

This is the same relationship in the other direction: matter–antimatter rest energy and motion become photon energy.

For the correspondence note, the important distinction is already visible:

Light carries energy and momentum without rest mass. Matter has rest mass and can persist in slower, localised forms. Under the right conditions, photon energy can be reorganised into massive particle–antiparticle pairs, provided conservation laws are satisfied.

The first photon question

The first matter did not need to come from one photon crashing into itself. In standard physics, a lone photon in empty space cannot turn into an electron–positron pair, because energy and momentum cannot both be conserved.

The deeper point is that the early universe was probably not a quiet empty space containing one lonely photon. It was a hot, dense state in which fields were excited together. Photons, charged particles, antiparticles, and other field excitations were continually being created, destroyed, scattered, and re-created.

So the first matter-like excitations did not need one photon to self-annihilate. They arose from interactions in a dense field environment where energy and momentum could be shared.

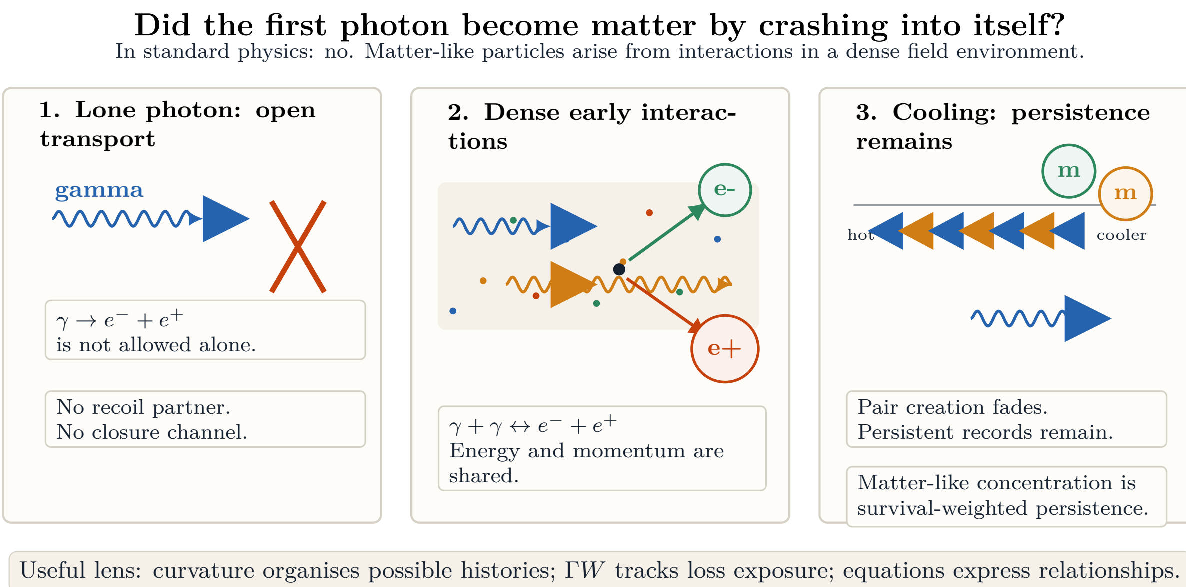

Figure 3: A lone photon is not enough, but a hot dense early universe provides an interacting field environment in which light-like excitations and matter-like excitations can transform into one another.

The phrase "sum over all possible trajectories" is useful, but it should not be read as the photon searching for a route. In quantum theory, the path integral is a way of calculating probability amplitudes. The mathematics represents all allowed histories, and histories that violate conservation laws cancel out or contribute zero.

So a photon does not find the path where it can crash into itself. Rather, the equations express which interactions have non-zero amplitude. A lone photon becoming a massive pair in empty space has no allowed amplitude because the conservation relationships do not close.

$$E^2 = p^2c^2 + m^2c^4 \tag{24}$$

In this relation, E is total energy, p is momentum, m is rest mass, and c is the speed of light.

For a photon:

$$m = 0 \tag{25}$$

so:

$$E = pc \tag{26}$$

For matter:

$$m > 0 \tag{27}$$

so some energy is present as rest mass.

The problem with one photon is that it has momentum. If it became an electron and positron pair by itself, there would be no way to satisfy both the energy and momentum bookkeeping in the centre-of-mass sense. With two photons coming from different directions, or with a nearby nucleus or field, the missing recoil can be carried away.

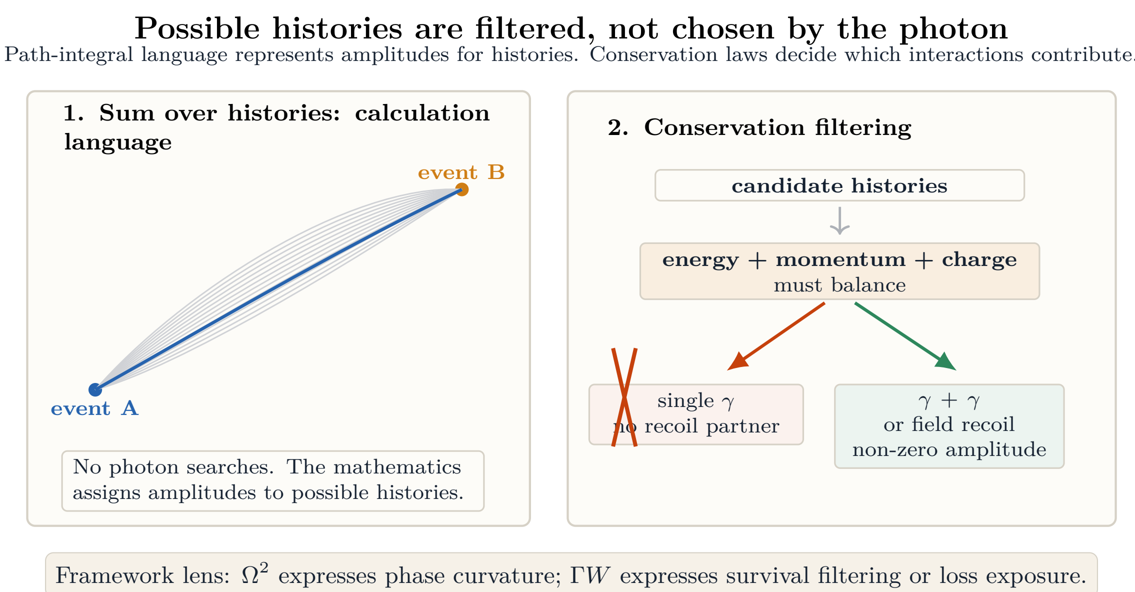

Figure 4: Path-integral language is a calculation language. It represents possible histories, while conservation laws filter which histories can contribute to a real physical outcome.

Photons, electrons, and the photoelectric threshold

Nicholson's useful shorthand was:

> Photons can stack; electrons exclude.

The more precise version is that photons are bosons, so many photons can occupy the same quantum mode. Electrons are fermions, so no two electrons can occupy the exact same quantum state. This is Pauli exclusion for fermions, not a failure of electrons to be close together in ordinary space.

That distinction matters for the photoelectric effect. For a bound atomic transition, a photon is most strongly absorbed when its energy matches an allowed gap:

$$E_\gamma = hf = \Delta E. \tag{28}$$

That is why atoms have spectral lines. The electron cannot move into just any bound energy; the atom has allowed states.

For the photoelectric effect, the rule is threshold-like rather than exact-gap-like. The incoming photon must carry at least the work function or binding energy ϕ:

$$hf \geq \phi. \tag{29}$$

If $hf < \phi$, ordinary low-intensity illumination does not eject the electron, no matter how many individually insufficient photons arrive. If $hf \geq \phi$, the surplus energy appears as kinetic energy of the emitted electron:

$$K_{\text{max}} = hf - \phi. \tag{30}$$

The photon also carries momentum:

$$p_\gamma = \frac{E_\gamma}{c} = \frac{hf}{c}. \tag{31}$$

So light can push. When photons are absorbed, reflected, or scattered, they transfer momentum to matter. Absorption transfers roughly p_γ. Reflection can transfer roughly $2p_\gamma$, because the photon reverses direction. The effect is tiny in ordinary sunlight but real in radiation pressure, solar sails, optical tweezers, and high-intensity laser systems.

Non-closing transport

A photon is better thought of as an excitation of the electromagnetic field than as a bead flying through space. Before detection it is represented by a quantum state with possible interactions spread over a region. At detection, the record is local. The photon is absorbed, scattered, or converted into a material mark.

Typical absorption-based measurement looks like this:

$$\gamma \to \text{electron excitation} \to \text{avalanche/current/chemical change/screen flash/click}. \tag{32}$$

After that event, the original photon is not still travelling as that photon. Its energy and momentum have become part of the detector, atom, surface, or measurement history.

This is where Nicholson's phrase "temporally non-local" earns a narrow meaning. A photon has no rest frame. It is carried by phase, not by a private little clock. It does not become a dated object in the ordinary sense until an interaction leaves a record. That is not mysticism, and it is not outside causality. It is simply one of the ways light refuses to behave like a small piece of matter.

Maxwell, Zen, and field-depth

Maxwell's relation gives the physical version of this dependence on a field. In a homogeneous, isotropic medium,

$$v = \frac{1}{\sqrt{\mu\epsilon}}, \tag{33}$$

where ϵ is permittivity and μ is permeability. In vacuum,

$$c = \frac{1}{\sqrt{\mu_0\epsilon_0}}. \tag{34}$$

Permittivity says how strongly the medium can be polarised by an electric field. Permeability says how strongly it supports magnetic field structure. Together they determine how fast electromagnetic phase can move through that medium.

This is the right place for the Zen metaphor. *Mu* is not blank absence. It is no-thingness: openness before a fixed object has been carved out. *Ma* is the interval, the meaningful between. *Basho* is place, the condition in which appearing can occur. These are not decorative terms. They keep emptiness active by refusing to turn it into mere lack.

So the analogy becomes simple. Let ϵ name receptivity: the capacity to be affected, polarised, informed. Let μ name field-depth: the open place that permits relation. Then v is not the speed of a little soul-particle. It is the rate at which a relation can propagate when receptivity and openness are coupled.

As pseudo-mathematics, one could write the analogy in dimensionless form:

$$\rho = \frac{\epsilon}{\epsilon_0}, \qquad \beta = \frac{\mu}{\mu_0}, \qquad n_{\rm rel} = \sqrt{\rho\beta}. \tag{35}$$

Here ρ is receptivity, β is basho or field-depth, and $n_{\rm rel}$ is the relational index: the amount by which open propagation has become mediated by a place. The corresponding symbolic propagation rate is

$$v_{\rm rel} = \frac{c}{n_{\rm rel}} = \frac{c}{\sqrt{\rho\beta}}. \tag{36}$$

This is not a new physical constant. It is a notation for the metaphor: awareness, appearance, or relation does not move through emptiness alone. It moves through the product of receptivity and place.

To express the moment where passage becomes record, introduce a schematic closure diagnostic:

$$\chi_{\rm app} = \rho\,\beta\,|\Delta\varphi|. \tag{37}$$

Here $\Delta\varphi$ is a phase difference, disturbance, or unresolved tension. If

$$\chi_{\rm app} < \chi_{\rm rec}, \tag{38}$$

the relation remains passage. If

$$\chi_{\rm app} \geq \chi_{\rm rec}, \tag{39}$$

the relation has enough coupling to leave a record: absorption, memory, objecthood, or physiological regulation.

There is also a useful impedance-like companion:

$$Z_{\text{rel}} = \sqrt{\frac{\beta}{\rho}}. \tag{40}$$

When ρ and β rise together, propagation can slow while Z_{rel} stays balanced. In the metaphor, that is a state where experience thickens without necessarily becoming reflective or obstructed. In the optical bookkeeping language, this echoes the familiar distinction between changing a propagation index and changing an impedance.

If the medium thickens, light slows, refracts, stores energy, and begins to look less like pure passage. If the medium is vacuum, light reaches the limiting case:

> motion without rest, presence without possession, phase without a material frame.

The playful formulation is therefore not throwaway:

> Maxwell may have accidentally written a very good Zen equation.

It says that propagation is never just a traveller. It is traveller, susceptibility, and place.

Boundary and objecthood

Traian Surtea's topology gives this a second, more formal vocabulary. In that setting a universe is written

$$\mathcal{U} = (M, \mathcal{D}), \tag{41}$$

where M is an underlying set and $\mathcal{D}$ is a partition of M. The elements $D \in \mathcal{D}$ are called D-photons. They are topological atoms of the partition, not automatically QED photons, but they are suggestive in exactly the right way: objecthood begins from how a support is cut, joined, bounded, and made available for interaction.

For a support X, Surtea's boundary can be written

$$\text{bd}_{\mathcal{D}}(X) = \text{cl}_{\mathcal{D}}(X) \setminus \text{int}_{\mathcal{D}}(X). \tag{42}$$

That boundary is not a decorative edge. It is the field or capacity of interaction. A photon in the ordinary physics story becomes visible when it is absorbed into an allowed transition. A D-photon in Traian's formal story belongs to the partition structure through which support, interior, closure, and boundary are defined. The bridge is not identity; it is rhyme.

Nicholson's photon idea can then be phrased without forcing it:

> Photon-like transport is open until a boundary gives it a place to register.

Recursive Survival Geometry adds the next layer. It does not ask only what can happen. It asks which generated histories persist strongly enough to remain represented. Light-like behaviour is the non-closing, norm-preserving limit. Matter-like behaviour appears where phase, conservation, interaction, and recurrence settle into records that survive.

This also keeps the "photons stack, electrons exclude" point in view. Photons, as bosons, can share a mode. Electrons, as fermions, cannot occupy the same quantum state. In the metaphorical register, photons show open mode-sharing transport; electrons show exclusion-structured persistence. One carries phase freely. The other helps build the occupancy structure of matter.

The phase-space dream

So, is this a dream in phase space? Better: a dream is phase-space without the same external closure pressure as waking measurement. It is not light flying inside the head. It is internally generated relation exploring possible configurations before the world pins them down.

The same contrast keeps returning:

- light: open propagation without rest-frame possession;
- matter: persistence through record, recurrence, and constraint;
- Surtea objecthood: support, interior, closure, boundary, and class;
- RSG observation: generated histories filtered by survival;
- dream: internally sustained phase relation before hard external record.

That makes consciousness less like a passenger moving through the void and more like a coupling between susceptibility and place. Being appears where the open field is receptive enough, and the receptive process is stable enough, for a relation to hold.

Light entering physiology

Vitamin D is perhaps the neatest biological example. Ultraviolet-B photons are absorbed by 7-dehydrocholesterol in the skin, producing previtamin D3, which thermally isomerises into vitamin D3. The photon is gone as a photon. Its transported energy has become molecular rearrangement.

That rearrangement then enters the body's transport system. Vitamin D metabolites are carried, modified by liver and kidney chemistry, and folded into calcium regulation, immune signalling, metabolism, and timing. So vitamin D is not "stored light" in the naive sense. It is better than that. Solar radiation becomes molecular configuration, then circulating signal, then physiological state.

Iodine and the thyroid may belong nearby, but more cautiously. Iodine is not a general light-storage medium. Stable iodine only "moderates radiation" in a specific medical sense: it can reduce thyroid uptake of radioactive iodine when given at the right time. Still, thyroid chemistry is relevant to the larger pattern because it converts environmental availability into endocrine timing, metabolic rate, temperature regulation, and organism-level state.

The biological pattern is therefore:

$$\text{radiation/energy} \to \text{absorption} \to \text{molecular change} \to \text{transport} \to \text{physiological regulation.} \tag{43}$$

That is light becoming record through life.

Propagation and record

The physics remains ordinary: photons carry energy and momentum; matter appears only when conservation laws and interaction channels allow it. The speculative gain lies in how the pattern repeats. Light is the least burdened case of propagation. Matter is propagation that has found recurrence, boundary, and record. In Zen terms, this is the open condition of appearing. In Traian's topology, it is support and boundary. In RSG, it is the survival of some histories strongly enough to remain represented.

Taken together, the point is not that consciousness is literally electromagnetic radiation. The point is stranger: light shows what unpossessed propagation looks like, and matter shows what happens when propagation learns how to stay.