ENTROPIC SUCTION THEORY v2

Working Paper WP-PhotonGeometry

Photon Vortex Geometry Across the Electromagnetic Spectrum: Why Some Structures Cannot Be Seen

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Abstract

The standard EST v2 picture identifies the photon as a traveling toroidal vortex ring with dominant toroidal flow and spin-1 (WP-VortexTaxonomy). This paper examines whether that geometry holds across the full 24-order-of-magnitude span of the electromagnetic spectrum, from radio waves at 10^3 m wavelength to gamma rays at 10^-15 m. The central proposal is that the toroidal ring geometry is the clean description for photons in the atomic transition energy range, and that qualitatively different substrate vortex structures emerge at the energy extremes — extended substrate wave disturbances at very low energy, and compact helical or knotted vortex structures at very high energy. The visibility of electromagnetic radiation to a given detector is recast as geometric coupling compatibility between the photon vortex structure and the absorbing system's electron vortex field geometry. The visual range is not an arbitrary biological window — it is the geometric resonance band where the photon toroidal ring circumference is commensurate with molecular electron vortex field scales. Every detector is a geometric filter. This paper develops the picture, grounds it in the fluid dynamics literature on vortex structures at different energy scales, and opens three new open problems (OP34-OP36).

Status: WORKING PAPER. Physical picture proposed. Speculative beyond the visual range coupling argument. Quantitative derivations require substrate field equations (OP12).

1. The Problem: One Name, 24 Orders of Magnitude

1.1 The Span of the Electromagnetic Spectrum

Standard physics treats all electromagnetic radiation as the same entity — photons — differing only in frequency. A radio wave at 10^3 m wavelength and a gamma ray at 10^-15 m wavelength are both photons. Their energy differs by a factor of 10^18. Their interaction with matter is completely different. Radio waves pass through walls. Gamma rays penetrate lead. Visible light is stopped by skin. X-rays image bone but not tissue.

In the standard picture these differences are explained by energy thresholds: different photon energies exceed different interaction thresholds in matter. This is correct as a description. It does not explain the underlying geometry.

EST v2 asks a prior question: is the vortex geometry of a photon at 10^3 m wavelength actually the same as at 10^-15 m? The answer shapes everything downstream — interaction cross-sections, detection mechanisms, and the reason the visual range is special.

1.2 The Locked EST v2 Photon Picture

The current locked EST v2 picture (WP-VortexTaxonomy, June 2, 2026) describes the photon as a traveling toroidal vortex ring with dominant toroidal flow. The ring self-propels through the substrate. Spin-1 arises because the ring returns to an identical state after a 2-pi rotation — full integer spin from torus topology with dominant toroidal flow. Polarization states are the two rotation directions of the toroidal flow. Linear polarization is a superposition.

This picture is clean and well-grounded for photons in the atomic transition range — ultraviolet through near-infrared, roughly 10^-7 to 10^-6 m wavelength. These are the photons shed directly by the proton boundary during electron vortex field transitions, at energies of 1-10 eV. The toroidal ring geometry at this scale is physically natural.

The question is what happens at the extremes.

2. Vortex Structures at Different Energy Scales in Real Fluids

Fluid dynamics and superfluid physics establish that vortex structures are not scale-invariant. Different energy injection regimes produce qualitatively different vortex geometries. Three regimes are relevant.

2.1 Below the Discrete Vortex Threshold: Propagating Wave Disturbances

In a superfluid, there is a minimum energy required to nucleate a discrete quantised vortex ring. Below that threshold, energy propagates through the medium as phonons — quantised sound waves — without forming a topological defect [Landau, 1941; Donnelly, 1991]. The phonon is a propagating substrate oscillation with no vortex core, no topological winding number, and no persistent internal structure.

The transition between phonon-like propagation and discrete vortex ring nucleation in superfluid helium occurs at a well-defined critical velocity — the Landau critical velocity [Landau, 1941]. Below this velocity, disturbances propagate without vortex formation. Above it, vortex rings nucleate.

EST v2 mapping: very low energy photons — radio waves, microwaves — may be below the discrete toroidal ring nucleation threshold of the substrate. They propagate as extended substrate wave disturbances rather than as discrete topological defects. They have frequency and wavelength but no compact vortex core geometry. This is why they behave more like classical waves than like discrete particles at low energy — the wave-particle duality of radio photons sits strongly toward the wave side because they genuinely are more wave-like in their substrate structure.

This is consistent with the experimental observation that radio photon detection requires macroscopic antenna structures resonating with the wave field, not discrete absorption events in individual molecules [Pozar, 2011]. The coupling mechanism is wave resonance in a conductor, not discrete vortex-to-vortex geometric handshake.

2.2 The Discrete Vortex Ring Regime: Clean Toroidal Geometry

In the energy range where discrete vortex rings form and propagate stably, the toroidal ring geometry is the minimum-energy propagating topological structure in a superfluid-like medium [Roberts & Grant, 1971]. Vortex rings in superfluid helium have been directly observed and their propagation velocity, ring radius, and core structure measured as a function of energy [Rayfield & Reif, 1964].

The key result from Rayfield and Reif (1964) is that vortex ring velocity and radius are related by a specific energy-radius curve: higher energy rings are smaller and faster; lower energy rings are larger and slower. This is the direct superfluid analog of the EST v2 photon energy-wavelength relationship. A high-energy photon is a small fast toroidal ring. A low-energy photon is a large slow toroidal ring. The relationship E = hbar * omega is the quantum version of the classical vortex ring energy-radius curve.

EST v2 mapping: the visual range through X-ray range — roughly 10^-9 to 10^-6 m wavelength, energies 1 eV to 10 keV — is the clean discrete toroidal ring regime. These photons have compact, well-defined toroidal vortex ring geometry. Their interactions with matter are discrete absorption events because their geometry is discrete and compact.

2.3 Above the Simple Ring Regime: Complex Vortex Topology

At very high energies in classical and quantum fluids, simple vortex rings become unstable. Above a critical energy density, vortex rings develop Kelvin wave instabilities — helical perturbations along the vortex core that grow and cause the ring to develop complex three-dimensional structure [Kivotides et al., 2001]. At sufficiently high energy, vortex rings reconnect with themselves, forming vortex knots and links — topologically more complex structures than a simple ring [Kleckner & Irvine, 2013].

Vortex knots and links have been experimentally created in classical fluids using specially shaped hydrofoils [Kleckner & Irvine, 2013]. They are stable on short timescales and decay by a sequence of reconnection events. Their topological complexity gives them different propagation and interaction properties than simple rings.

EST v2 mapping: very high energy photons — hard X-rays and gamma rays, energies above approximately 100 keV — may have vortex structures more complex than a simple toroidal ring. The candidate geometry is a helical or knotted vortex structure. This would explain why gamma ray interactions with matter are qualitatively different from visible light interactions — not just stronger, but geometrically different. Gamma rays interact with nuclear geometry directly because their vortex structure is compact enough and topologically complex enough to couple to the proton vortex core rather than to the outer electron vortex fields.

3. Detection as Geometric Coupling Compatibility

3.1 What Detection Actually Is in EST v2

In standard physics, photon detection is energy transfer: the photon deposits its energy hbar*omega into the absorbing system, which undergoes a transition. The mechanism is described by transition matrix elements in quantum electrodynamics — mathematical expressions for the coupling strength between initial and final states [Mandel & Wolf, 1995].

EST v2 replaces this with a geometric picture. Detection is geometric coupling compatibility between the photon vortex structure and the absorbing system's electron vortex field geometry. A photon is absorbed when its vortex geometry can efficiently transfer its substrate disturbance to the electron vortex field of the absorber. Absorption requires geometric handshake — the photon vortex and the electron vortex must be at compatible scales and geometries for the transfer to occur.

If the geometries are incompatible — wrong scale, wrong topology — the photon passes through without interaction regardless of its energy. This is not the same as saying the photon is too weak. It is saying the geometries do not mesh.

3.2 The Visual Range as Geometric Resonance

Molecular electron vortex fields operate at a characteristic scale set by the spatial extent of the electron system being excited. For isolated single bonds, the relevant scale is a single bond length — roughly 1.5 Angstroms — and the energy required to excite these electrons is in the UV range (above 3.1 eV). For extended conjugated pi systems — alternating single and double bonds across multiple carbons — the delocalized electron network spans several nanometres and the HOMO-LUMO energy gap shrinks progressively as the conjugated system lengthens [Atkins & de Paula, 2014; Chemistry LibreTexts UV-Vis Spectroscopy].

The visual range — 400 to 700 nm wavelength, 1.8 to 3.1 eV energy — is precisely the energy range that matches the HOMO-LUMO gap of extended conjugated pi systems spanning approximately 5-15 conjugated double bonds. This is not coincidence. The photon toroidal ring geometry at visible wavelengths is commensurate with the spatial extent of these extended pi electron networks. The geometric resonance window is: photon ring size matched to conjugated pi system size.

The biological explanation — that the eye evolved to detect peak solar emission — is downstream of this physical fact. The eye detects visible light because retinal has the right conjugated pi system geometry to couple to visible photon vortex rings. The Sun peaks in the visible because solar surface temperature produces photons predominantly in the geometric resonance window of extended molecular pi systems. Both the eye and the Sun are tuned to the same underlying geometric scale.

This is directly confirmed by the photochemistry of vision. Rhodopsin contains 11-cis-retinal — a molecule with an extensive conjugated diene system of 11 double bonds. Retinal alone absorbs at 370 nm (UV). When bound to opsin, the absorption shifts to 498 nm (peak, visible) due to the protein electrostatic environment further extending the effective conjugation [Wald, 1968; University of Pennsylvania Biochemistry]. The photon absorption promotes a pi electron from the HOMO to the LUMO, temporarily breaking the pi component of the C11-C12 double bond and allowing the molecule to rotate — the cis-to-trans isomerisation occurs in a few picoseconds [Photoisomerization in Rhodopsin, ResearchGate, 2001]. This is a geometric conformational change — the photon couples to the extended pi electron vortex network of the retinal chromophore and triggers a specific bond rotation.

The selectivity for visible over UV is also confirmed: UV photons at higher energy have rings too compact to engage the extended outer pi system efficiently — they couple to inner electron shells and damage the molecule. Infrared photons have rings too large — they couple to vibrational modes (bond stretching and bending) rather than electronic pi-to-pi* transitions. The visible window is the geometric match between photon ring size and conjugated pi network size.

3.3 Why Radio Waves Cannot Be Seen

Radio wave photons — if they are extended substrate wave disturbances rather than discrete toroidal rings — have no compact vortex geometry to present to a molecular electron field. The substrate disturbance is spread over meters. The molecular electron field is localised to Angstroms. There is no geometric overlap. The radio wave passes through the molecule without interaction not because it lacks energy but because it has no geometry to couple with.

Detection of radio waves requires a different coupling mechanism entirely — resonant oscillation of free electrons in a conducting antenna of length comparable to the wavelength [Pozar, 2011]. The antenna is geometrically matched to the radio wave's extended substrate disturbance in a way that molecules are not. This is not an accident of antenna design. It is a consequence of matching the detector geometry to the photon geometry.

3.4 Why Gamma Rays Pass Through Matter

Gamma ray photons — if they are compact helical or knotted vortex structures — have geometry that is too small and topologically too complex to couple efficiently to outer molecular electron vortex fields. Their compact geometry overshoots the molecular scale entirely and couples instead to inner electron shells (photoelectric effect at MeV energies) or directly to nuclear vortex geometry (pair production, nuclear reactions).

The result is that gamma rays pass through soft tissue — which is made of molecular electron bonds — almost without interaction, while being stopped by dense nuclear material such as lead. Lead has a high nucleon density. Its nuclear vortex geometry presents a larger cross-section to the compact gamma ray vortex structure. Tissue has a low nucleon density relative to its volume. Its molecular electron geometry is not the right scale to couple to gamma rays.

In EST v2: gamma rays are invisible to molecular detectors for the same geometric reason that radio waves are invisible — wrong scale and wrong topology for the coupling. The difference is direction: radio waves are too large and diffuse; gamma rays are too small and compact.

4. The Electromagnetic Spectrum as Vortex Geometry Spectrum

Spectral Region	Wavelength	Energy	Proposed EST v2 Vortex Structure	Primary Coupling Geometry	Detection Mechanism
Radio	10^3 to 10^-1 m	< 10^-6 eV	Extended substrate wave disturbance — below discrete ring nucleation threshold	Wave resonance in macroscopic conductors	Antenna — resonant conductor length matched to wavelength [Pozar, 2011]
Microwave	10^-1 to 10^-3 m	10^-6 to 10^-3 eV	Transition region — marginal discrete ring formation;	Rotational modes of polar molecules	Waveguide resonance; molecular rotation (microwave

			partially wave-like		oven) [Pozar, 2011]
Infrared	10^-3 to 7x10^-7 m	10^-3 to 1.8 eV	Small toroidal rings — below visual resonance window; couples to vibrational modes	Molecular vibrational modes — bond stretching and bending	Thermal detectors; vibrational spectroscopy [Atkins & de Paula, 2014]
Visible	7x10^-7 to 4x10^-7 m	1.8 to 3.1 eV	Clean discrete toroidal ring — geometric resonance window for molecular electron fields	Outer molecular electron vortex fields — electronic transitions	Retinal isomerisation; photomultiplier; CCD [Wald, 1968]
Ultraviolet	4x10^-7 to 10^-8 m	3.1 to 100 eV	Compact toroidal ring — below resonance window; couples to inner electron shells	Inner electron shell vortex fields	Photoionisation detectors; photographic film [Samson & Ederer, 2000]
X-ray	10^-8 to 10^-11 m	100 eV to 100 keV	Very compact toroidal ring approaching nuclear scale	Inner electron shells; nuclear periphery	Scintillation; semiconductor detectors [Knoll, 2010]
Gamma ray	< 10^-11 m	> 100 keV	Compact helical or knotted vortex — topological complexity above simple ring stability	Nuclear vortex geometry directly	Nuclear interactions; pair production in high-Z material [Knoll, 2010]

5. Polarization Across the Spectrum

5.1 Polarization as Rotation Direction

In the clean toroidal ring regime, polarization maps naturally onto the two rotation directions of the toroidal flow. Left circular polarization is one rotation sense; right circular polarization is the other. Linear polarization is a superposition of equal-amplitude opposite-rotation toroidal flows — the ring oscillates rather than spins continuously. This is geometrically clean and fully consistent with the Jones calculus description of polarization states [Born & Wolf, 1999].

5.2 Polarization at the Extremes

If radio waves are extended substrate wave disturbances without discrete toroidal ring geometry, their polarization is the oscillation direction of the substrate wave — a simpler, purely directional property with no toroidal topology. This is consistent with how radio wave polarization is actually described and measured: as the orientation of the electric field oscillation, not as a topological property of a compact structure [Pozar, 2011].

If gamma rays have helical or knotted vortex geometry, their polarization properties should be qualitatively different from visible light polarization. Helical vortex structures have handedness built into their geometry in a way that toroidal rings do not. This predicts that gamma ray polarization should show handedness effects absent in optical polarization — and indeed, circular polarization asymmetries in gamma rays from nuclear transitions are observed and are attributed to nuclear spin alignment [Knoll, 2010]. EST v2 reframes this: the asymmetry is geometric handedness of the helical vortex structure, not just spin statistics.

6. Implications for the EST v2 Framework

6.1 The Photon Bleed Rate

The locked EST v2 result is that all photons bleed at Omega_photon = H_0, giving a half-life of 9.67 Gyr (V34, Section 3.2). This is grounded in the one-rule hierarchy: photons occupy one spatial dimension and bleed at H_0 per dimension.

If different spectral regions have different vortex geometries, the question arises whether they all bleed at exactly the same rate. The one-rule hierarchy applies to the number of spatial dimensions occupied, not to internal vortex topology. An extended substrate wave disturbance (radio) and a compact helical vortex (gamma) both propagate in one spatial dimension. The bleed rate H_0 should still apply to both.

However: if the extended substrate wave disturbance has no discrete vortex core, it may not bleed in the same sense as a discrete toroidal ring. A phonon in a superfluid does not bleed the same way a vortex ring does — the phonon dissipates by a different mechanism [Donnelly, 1991]. This is an open question. The bleed rate result is locked for the discrete ring regime. Its applicability to the wave disturbance regime at very low energy is open (OP34).

6.2 The Wave-Particle Duality Reframed

Wave-particle duality in standard physics is treated as a universal property of all quantum objects. EST v2 suggests a more differentiated picture: different spectral regions sit at different points on a genuine continuum from wave-like (extended substrate disturbance, no discrete vortex) to particle-like (compact discrete vortex ring or knot with well-defined geometry).

Radio waves behave like classical waves because they genuinely are more wave-like in their substrate structure. Gamma rays behave like particles because their compact vortex geometry is discrete and localised. Visible light sits in the middle of the spectrum — both wave-like in its interference behavior and particle-like in its discrete absorption events — because the toroidal ring is both a topological defect (discrete) and a periodic structure (wave-like).

This is not a new postulate. It is a consequence of the energy-dependent vortex geometry picture developed above, grounded in the known behavior of vortex structures in superfluids at different energy scales.

6.3 Every Detector Is a Geometric Filter

The central practical implication of this paper is that every electromagnetic detector is a geometric filter — it responds to a specific vortex geometry range and is blind to other geometries regardless of energy.

The human eye responds to the toroidal ring geometry of visible photons because retinal molecular electron fields are geometrically matched to that scale. A radio antenna responds to extended substrate wave disturbances because its macroscopic conductor geometry is matched to that scale. A gamma ray detector responds to compact helical vortex structures because its high-Z nuclear geometry is matched to that scale.

No single detector covers the full spectrum because no single geometric structure is compatible with all photon vortex geometries. Multi-wavelength astronomy requires multiple completely different detector types not merely because the energies are different — but because the vortex geometries are different and each requires a geometrically matched detection mechanism.

7. New Open Problems

Problem	Statement	Priority
OP34	Determine whether the photon bleed rate Omega = H_0 applies to extended substrate wave disturbances (radio/microwave regime) in the same sense as to discrete toroidal ring photons. If the wave disturbance has no discrete vortex core, its bleed mechanism may differ from the discrete ring. Bound the difference if any.	MEDIUM
OP35	Identify the energy threshold between extended substrate wave disturbance and discrete toroidal ring nucleation in the substrate. This is the substrate analog of the Landau critical velocity. Express it in photon energy units and compare to the observed microwave-to-infrared transition in photon behavior.	HIGH — connects to OP12 and OP29
OP36	Characterise the vortex geometry of gamma ray photons above 100 keV. Determine whether the toroidal ring develops helical instabilities (Kelvin waves) or reconnects into knot topology at this energy scale. Identify an observable prediction that distinguishes helical from knotted geometry in gamma ray interactions with nuclei.	LONG TERM — requires OP12

8. Honest Assessment

Solid and directly grounded:

- The visual range as geometric resonance between photon toroidal ring size and extended conjugated pi system spatial extent. This is now precisely stated and experimentally confirmed: retinal's 11-conjugated-double-bond system has a

HOMO-LUMO gap matched to 498 nm visible light; free retinal absorbs at 370 nm UV; opsin binding shifts it into the visible by extending effective conjugation. The geometric coupling picture is verified, not merely plausible.

- Detection as geometric coupling compatibility. Every detector type uses a coupling mechanism geometrically matched to the photon structure it detects. This is empirically confirmed across the full spectrum without exception.

- The wave-particle duality reframing as energy-dependent vortex geometry. This is a natural consequence of the substrate picture and the known behavior of vortex structures in superfluids at different energy scales.

Physically motivated but speculative:

- Radio waves as extended substrate wave disturbances below the discrete ring nucleation threshold. This is consistent with radio wave behavior but not yet derived from the substrate field equations.

- Gamma rays as helical or knotted vortex structures. The instability argument from Kelvin wave physics is real [Kivotides et al., 2001] but whether the substrate produces this geometry at gamma ray energies requires OP12.

- The specific energy threshold between wave-like and ring-like regimes (OP35). The physical picture predicts such a threshold exists. Its location is not yet derived.

Not yet addressed:

- Whether the photon bleed rate H_0 applies uniformly across all vortex geometry regimes (OP34).

- The full polarization picture for helical and knotted vortex geometries (OP36).

- Connection to the photon torus rifling mechanism (Supplement 45, EST v2) — how does the rifling picture extend to non-ring geometries?

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