Segmented Spacetime - Maxwell Waves as Rotating Space

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We reinterpret Maxwell's equations as manifestations of local space rotation within a segmented spacetime geometry. Using a 1+3 decomposition, we identify vorticity terms that couple geometry to the electromagnetic field, showing that waves arise from twisting space rather than fields oscillating in a fixed background. This yields a Coriolis-like interaction that splits the two circular polarizations and induces a small, geometry-driven rotation of polarization while preserving the constancy of light speed. In the Segmented Spacetime framework, the rotational field emerges naturally from spiral segmentation, predicting helicity-dependent phase shifts and polarization rotation along spiral paths. The analysis supports a unified view in which electric and magnetic components are orthogonal projections of a single geometric process: the local rotation and segmentation of space.

In vacuum, Maxwell's equations can be written compactly as:

$$dF = 0$$

$$d * F = 0$$

Here, F is the electromagnetic field tensor and * (the Hodge operator) depends directly on the space-time geometry g. If the geometry itself changes - for instance, if space locally rotates or twists - then even without any charges, the equations gain additional terms purely from geometry.

1. Space Rotation in the 1+3 Decomposition

We split space-time into a time direction (defined by an observer's 4-velocity u) and spatial slices orthogonal to u. From this, the electric and magnetic fields are defined as:

$$E_{\mathrm{a}} = F_{\mathrm{a}} b\, u^{\mathrm{b}}$$

$$B^{\mathrm{a}} = ½\, \varepsilon^{\mathrm{a}} bcd\, u_b\, F_{cd}$$

These are purely spatial: $E \cdot u = 0,\ B \cdot u = 0.$

When we decompose the derivative of the observer field ∇_au_b, we find four components:

expansion (θ),

shear (σ),

vorticity (ω),

and acceleration (a).

If we now rewrite Maxwell's equations in this 1+3 form, we obtain:

$$\dot{E} \;=\; curl\, B \;-\frac{2}{3}\theta\, E \;-\; \sigma \cdot E \;+\; \omega \;\times\; E$$

$$\dot{B} \;=\; -curl\, E \;-\frac{2}{3}\theta\, B \;-\; \sigma \cdot B \;+\; \omega \;\times\; B$$

$$div\, E \;=\; 0, \qquad div\, B \;=\; 0$$

The crucial part is the ω × (...) term: This is not caused by rotating fields in a fixed space. It appears because the space itself is rotating (vorticity of the spatial foliation). In other words, E and B are two orthogonal projections of a single geometric rotation of space.

2. The Wave Equation with Rotating Space

If expansion and shear are negligible (θ ≈ 0, σ ≈ 0), but the local vorticity ω is not, we can take the time derivative of the first equation and eliminate B to obtain:

$$\ddot{E} \;-\; c^2\, \nabla^2 E \;\approx\; \dot{\omega} \;\times\; E \;+\; \omega \;\times\; \dot{E} \;+ (higher - order\ curvature\ terms)$$

This is a wave equation with a Coriolis-like coupling. When space rotates, these extra terms appear automatically.

In a locally rotating frame (constant ω), the equation simplifies to:

$$\dot{E} \;-\; c^2\, \nabla^2 E \;=\; \omega \;\times\; \ddot{E}$$

The same applies for B. This shows that electromagnetic waves are the result of space rotating within itself, not something moving through space.

3. Dispersion Relation in a Rotating Geometry

For plane waves of the form

$$E(x,t) \;=\; \Re\{\, e_{\pm}\, E^0 e^{i(k\cdot x \,-\, \Omega t)}\}$$

with circular polarization, and assuming ω is parallel to k, we find:

$$\Omega^2 \;\mp\; \omega\Omega \;-\; c^2k^2 \;=\; 0$$

Solving for Ω gives:

$$\Omega_{\pm} = \frac{\omega}{2} \pm ½ \sqrt{\omega^2 + 4c^2k^2}$$

For weak rotation (ω ≪ c k), the frequencies are approximately:

$$\Omega_{+} \approx c\,k + \frac{\omega}{2}$$

$$\Omega_{-} \approx c\,k - \frac{\omega}{2}$$

Thus, the rotation of space causes a tiny frequency splitting depending on the wave's helicity (left or right circular polarization).

Space acts like a geometric optical medium with natural optical activity, but the speed of light, c, remains constant.

4. Application to Segmented Spacetime (SSZ)

In the SSZ framework, the local vorticity corresponds to the spiral segmentation of space.

Let the rotational field be:

$$\omega(r) = \omega^0 \left(\frac{r^0}{r}\right)^p, \ \ with\, p > 0$$

and directed tangentially along the ϕ-spiral arm.

For waves traveling along the spiral direction (k ∥ $\hat{\phi}$), the dispersion relation becomes:

$$\Omega_{\pm}(r,k) = \frac{\omega(r)}{2} \pm ½ \sqrt{\omega(r)^2 + 4\,c^2\,k^2}$$

In the weak-rotation limit (ω(r) ≪ c k):

$$\Omega_{\pm} \approx c\,k \pm \frac{\omega(r)}{2}$$

Hence, space's internal rotation produces:

- a helicity splitting $\Delta\Omega(r) \approx \omega(r)$,
- a geometric rotation of polarization given by $\Delta\Phi_{geo} \approx ½ \int \omega(r(s))\, ds$
- and a nearly unchanged group velocity $v_g \approx c$

This confirms the intuition that light is not moving through space, but rather that space itself rotates and segments, and the electric and magnetic fields are the visible projections of that rotation.

5. Summary for the Paper

When expressed in 1+3 form, Maxwell's equations show that a non-zero spatial vorticity adds ω × (...) terms, directly linking electromagnetic dynamics to the rotation of space itself.

For plane waves, this results in a helicity-dependent dispersion relation:

$$\Omega^2 \mp \omega\Omega - c^2k^2 = 0$$

producing a small frequency splitting $\Omega^+ \approx c\,k + \frac{\omega}{2}$, $\Omega^- \approx c\,k - \frac{\omega}{2}$.

Within the Segmented Spacetime model, where ω(r) arises naturally from spiral segmentation,

this provides a precise geometric mechanism for polarization rotation and phase shifts without violating the constancy of the speed of light.

References:

For complete derivations, code implementation, and data validation tests, please visit the full repository on GitHub *"*Segmented Spacetime – Mass Projection Unified Results"*,* where all experiments are reproduced with real observational data.

https://github.com/error-wtf/Segmented-Spacetime-Mass-Projection-Unified-Results