Electromagnetism

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Constants: CODATA-2022 (NIST SP 961, May 2024); portal physics.nist.gov/constants; accessed Sep 22, 2025.

Scope

This pillar covers electromagnetism as a consequence of loop-geometry and transport. We don't assume charge we derive its effects from geometry—no new dimensional scales beyond $S_0 = \hbar$ *(set once at the electron anchor; later anchors only verify)*. In the simple limit we recover Maxwell's equations. Structure beyond that limit enters only through geometry (index gradients, closure/orientation budgets). We work in vacuum first (spectral lines and line-ratios), then in media (how $n(\lambda)$ scales and steers rays). Calibration is local to the pillar, with ratio-first checks if they beat calibration, and explicit falsifiers when data disagree.

Coverage map:

Foundation — $S_0 = \hbar$; operators {Eκ, T, S, C}
$\rightarrow$ Maxwell limit (vacuum)
$\rightarrow$ Propagation in gradients: $n(\lambda, r)$, curvature balance $1/a = \|\nabla\perp \ln n\|$
$\rightarrow$ Spectroscopy (vacuum): Hα 656.281 nm, Hβ 486.133 nm, Hγ 434.047 nm; stable ratios
$\quad \rightarrow$ Wave optics: interference/diffraction (Fresnel/Fraunhofer); coherence hooks.
$\quad \rightarrow$ Polarization: Jones/Stokes transport; Brewster/Fresnel coefficients; Faraday as a medium add-on.
$\rightarrow$ Media predictions: $n(\lambda)$ scaling; graded-index transport

What Is Charge in VMS?

Short version: A "charged" thing here is a **rotating void-loop** that's constantly throwing off null-gravity waves (NGWs) **ripples**. Those ripples don't pile anything up—no net space-density change. Another loop only feels something if **it's also spinning** and **its facing lines up** with the ripple pattern. The effect is **purely orientation-gated**.

Right spin, right facing $\rightarrow$ you get a push; wrong facing $\rightarrow$ the pushes cancel over a cycle and you feel nothing net. opposite facing you get a pull

1) Core picture — the surfer analogy (why this actually works)

Think of the second loop as a **surfer** and the NGW pattern as **ocean swell**. The swell isn't a "standing downhill"—it's a **traveling pattern**.

- If the surfer **angles the board** into the swell the right way, the **path bends** and you "catch" it.
- If you're **misaligned**, the chops shove you back and forth but **average out**—no net drift.

- If you're **faced the other way**, you get the **opposite** path change.

That's the charge interaction here: **path steering by alignment**. No alignment → no net change. Opposite alignment → opposite change. There's **no new stuff** in space doing the pushing; it's all in how a **spinning, oriented** loop rides the pattern.

2) Preferred plane from display-area expansion (why there's a "facing" at all)

Display-area merge contraction (closed-form).
For fragments with volumes $\{V_i\}$ that merge into one body:
F_merge = A_after / A_before = $(\sum_i V_i)^{2/3}$ / $(\sum_i V_i^{2/3})$ ≤ 1.

Two equal fragments V/2, V/2: F_merge = $V^{2/3}$ / [2 $(V/2)^{2/3}$] = $2^{-1/3}$ ≈ 0.7937 (inverse of split factor $2^{1/3}$).

When a loop splits and merges space along its route, **splitting expands display-area** and **merging contracts it**. That rule naturally picks out the **preferred plane** for the loop's motion from the caustic—on that plane the expansion/merging bookkeeping balances best. "Facing" is judged against that plane. The **sign** we call "positive" or "negative" is just **which direction**, counterclockwise vs clockwise locked to that common plane.

[Diagram] Loop orientation → expansion arrows → the picked preferred plane.

3) Sign, size, and steps (how much "charge," and why it comes in chunks)

- **Sign**: which side of the preferred plane the loop's orientation locks to.
- **Size**: how many **aligned turns per cycle** the loop contributes (an integer count when you coarse-grain over time).
- **Steps (quantization)**: you only change the count at **discrete orientation-flip or merge/split events**; it doesn't slide continuously when closure holds.

4) Continuity (nothing pops in from nowhere)

Orientation doesn't just appear or vanish away from real tear/closure events. So the **net "effect you feel" changes continuously in time** as loops move and re-align. That's the common-sense "nothing up my sleeve" rule—what we'll later formalize as the usual conservation statement, but the point here is physical: **no surprise jumps** unless you actually cross a defect.

[Sketch] Orientation flow lines showing smooth passage vs. a defect surface where in/out is accounted.

5) From geometry to the usual EM laws (why engineers recognize the result)

When you average these **orientation-gated path nudges** over time and over many loops—**in smooth, weak-curvature conditions**—the **effective path law** you recover is

the same set engineers already use: the **standard Maxwell equations**. We'll show that "Maxwell-limit" in the math walk-through; here the message is simple: **EM is the alignment-driven path steering, and its coarse-grained bookkeeping matches Maxwell.**

6) How this is not gravity (why orientation matters here but not there)

Gravity behaves like a **standing curvature gradient**—a downhill. Anything with inertia "rolls" the same way no matter how it's turned. **Electromagnetism here is different**: there's **no standing downhill**—just a **traveling pattern**—so the outcome **depends completely on how you're oriented**. Right facing → push. Wrong facing → it cancels. **Opposite facing → pull.**

Problem & Promise

Falsifier (pillar-level): sustained ≥3σ disagreement in stable line ratios or index-scaling ratios after instrument/systematic control; same rule for the neutral-rotor push/zero/pull and spin-flip sign tests.

The problem with the usual story: Classical EM is insanely predictive, but it **starts** by assuming "charge" and the rest of the furniture are already there. It doesn't tell you where that stuff *comes from*. In VMS, we don't assume it — we **build it** from geometry. "Charged" isn't a magic label; it's a **spinning void-loop** throwing off **NGW ripples**. There's **no standing downhill** like gravity. The only way another loop feels anything is if **it's also spinning** and its **facing lines up** with the pattern. Right spin, right facing → you get a push; wrong facing → the pushes cancel over a cycle and you feel nothing net; **opposite facing you get a pull**.

What we're promising:

1. We recover the **same equations engineers already use** — the Maxwell set — when you average these orientation-gated nudges in smooth, weak-curvature conditions. No new dials, no hidden units. Just the limit you know, from a cleaner origin story.
2. We show **where controlled corrections could live** — tied to torsion and shear — and we put hard gates on how big those can be before we call it wrong.
3. We publish **quantitative, falsifiable tests**: what to measure, how to judge pass/fail, and where a ratio-first estimate is the right operational choice.

In the real world — why bother if Maxwell already nails a lot of it

First, the truth: the everyday "orientation stuff" below is **already predicted by classical EM (Maxwell) / SM's QED**. That's not the point of VMS. The point is: we

don't assume charge; we build it from geometry, we explain **why** orientation gates the effect, we unify the intuition with gravity (no standing downhill here), and we **predict new orientation-gated behaviors** in regimes nobody is instrumenting yet. Maxwell is the right limit; VMS is the mechanism and the next set of tests.

What you already see (Maxwell explains it) — in plain talk:

- **Phones/links that "wake up" when you turn them.** Antennas are picky about **facing**. Line them up and it talks; turn 90° and it goes quiet (that's polarization-loss factor). DigiKey+1
- **RFID/NFC that only reads when the tag is "just so."** Parallel coils read; perpendicular is basically **zero** (vendor app notes say it exactly). STMicroelectronics+1
- **Wireless charging that's great when it snaps, bad when it doesn't.** Qi2 adds **magnets** to force the right plane because alignment matters for speed/heat. WIRED+1
- **Fiber links that "get moody" with heat/bends.** The glass has tiny preferred directions; when they drift you get **PMD** and smearing. Same facing story hiding in glass. RP Photonics
- **Space radar that sees rows of crops—or misses them.** Flip HH/HV/VV and scenes pop or disappear based on orientation. Everyday polarimetry. Descanso+1
- **Skies that rotate your facing.** The ionosphere rotates polarization (**Faraday rotation**); track it or your link fades. AGU Publications+1
- **Glare that vanishes at one angle.** Brewster's angle + a quarter-turn on polarizers and the glare dies. Same rule: right vs wrong facing. BU Physics

Why we bother: because our model says the effect **isn't standing downhill**—it's **alignment-driven path steering** from null-gravity-wave (NGW) patterns. That origin leads to **new, simple tests** that standard EM doesn't hand you:
Right spin, right facing → push; wrong facing → it cancels; opposite facing → pull.

New tests to run now (neutral, no hidden EM handles):

Expected scale (order-of-magnitude, to refine in Calibration/Appendix):

For a neutral micro-rotor of radius $r \sim 10^{-6}$ m, moment $I \sim 10^{-24}$ kg·m², spun at $\omega \sim 10^6$ s^{-1} in UHV, the predicted orientation-gated force/torque is sub-pN / sub-zN·m per cycle, rising with aligned surface speed and dropping sharply at null angles. Report both calibrated and ratio-based readouts (spin-flip lock-in recommended).

1. **Neutral, spinning loop → push/zero/pull in high vacuum.** Two neutral micro-rotors, isolated from EM coupling. Map three outcomes by facing alone: **push / cancel / pull**. The **"wrong-facing = zero"** is the tell.
2. **Spin-flip sign reversal with everything else fixed.** Keep geometry/materials constant; just flip the **spin sense** of the impacted loop. We predict **push↔pull**

flip; Maxwell has no stand-alone "spin-sense" lever in a neutral, non-current system.

3. **Sharp null-cones, not smooth roll-off.** Sweep relative orientation and publish the **angle map of zeros**. We expect **distinct nulls** at specific angles (not a gentle EM-style curve).
4. **Ratio-first spectroscopy with an orientation hook.** Where metrology is ultra-tight (e.g., hydrogen lines), publish the Maxwell-limit numbers **and** a small **orientation-tagged** correction band. Any **angle-tied split** beyond the calibrated band is a decisive falsification flag.
5. **"No standing downhill" checks.** Build rigs that would react to a gravity-like stationary gradient. We predict **no effect** unless facing is right; gravity analogs wouldn't care about facing.

There are public "anecdotes" of orientation-ish anomalies—but none cleanly match the push/zero/pull triad, and the best attempts either failed to reproduce or point to mundane systematics.

Here's the straight read:
What people have claimed (and where it stands)

- **Rotating superconductors (Podkletnov, 1990s):**
  Claimed "weight reduction" above a spinning YBCO disc. NASA's own summary says **MSFC tried to build a full replication but never finished**; a **private replication (Hathaway–Cleveland–Bao, 2003) saw no gravity-like force** at sensitivities far beyond the original claim. So: famous anecdote, **no confirmed effect**. NASA Technical Reports Server+2ScienceDirect+2 *(Background overview and pitfalls papers exist, but they reinforce how easy it is to fool yourself here.)* ResearchGate+1

- **Cryogenic rings & gyros (Tajmar, 2006–2008):**
  Reported **anomalous fiber-optic gyroscope signals** near spinning rings at low temperature, with odd "parity" dependence. Intriguing, widely discussed, **no consensus**; replications are sparse/inconclusive and the community remains skeptical. It's the closest "spin/orientation anomaly" with decent lab kit—but **not established**. arXiv+1

- **Eclipse pendulums (Allais effect):**
  Decades of mixed reports of pendulum/gravimeter blips during solar eclipses; multiple careful campaigns report **no unambiguous detection**. It's a classic "lots of anecdotes, no clean signal once controls improve." Wikipedia

- **"Reactionless thrusters" (EmDrive) as a cautionary tale:**
  Early positive thrusts got attention; **high-accuracy tests later traced them to thermal/fixture artifacts** and set strong null bounds. Moral: tiny forces are slippery. SpringerLink+1

- **State-of-the-art rotors/force sensors:**
  Today's levitated nanorotors hit **GHz spin** and **yocto/zepto-newton-scale torque sensitivity**. That means **we have the hardware** to test push/zero/pull claim

cleanly—even though no one has publicly reported this specific triad in a neutral, no-EM-handle setup. PubMed

Bottom line

- There **is** anecdotal smoke (superconductors; cryogenic rings; eclipse tales), but **no robust fire** that matches *our* prediction: **neutral, spinning loop → orientation-gated push / true zero / pull**, with a **spin-flip sign reversal**. The strongest "anecdotes" either **failed reproducibility** or can be **explained away** with known systematics. NASA Technical Reports Server+2ScienceDirect+2
- That's exactly why these tests matter: with modern UHV, neutral rotors, and lock-in on **spin-flip**, they can give this a **decisive yes/no** instead of folklore.

Of the pillars, **Electromagnetism** has the *fewest* non-standard, peer-reviewed experimental "wins" in the wild. In fact, EM is the most over-constrained arena in physics:

- **Coulomb's inverse-square law** has been hammered for a century; classic and modern tests push deviations to tiny levels. (E.g., Plimpton–Lawton verified the $1/r^2$ exponent to ~1 in 10^9; Williams–Faller–Hill recast null results as a tight upper bound on photon mass.) Physical Review+1
- The photon mass is bounded to be essentially zero by a zoo of methods (space/plasma timing, planetary magnetospheres, etc.); the 's 2024 review summarizes extremely stringent limits.
- High-profile "anomalies" haven't survived hard replications: **Podkletnov's** spinning-superconductor "gravity shielding" returned **null** in serious follow-ups; **EmDrive** thrust claims were beaten down by precision balances (Tajmar et al., 2021–2022). ScienceDirect+2ADS+2
- The one recurring curiosity—**Tajmar's cryogenic ring/gyro signals**—remains **unsettled** and unconfirmed by a broad community; it didn't turn into a standard effect. Semantic Scholar

So what's the point of this pillar? Two things:

1. **Origin story + mechanism.** Maxwell is the right limit; we're not trying to out-predict radio engineers. We're replacing "charge as a given" with a concrete *orientation-gated path-steering* picture (the surfer logic) that explains *why* alignment matters—then we use that to pose **new, clean tests** no one is running.
2. **New, decisive lab tests—enabled by today's hardware.** The kit now exists to check **push / zero / pull** triad in regimes **Maxwell doesn't** motivate (neutral objects, no applied fields, no currents): GHz-class **neutral rotors** and **zepto-newton** force/torque sensors in UHV are on the shelf. That makes a targeted **spin-flip lock-in** test realistic today. ScienceDirect+1

Key Point: EM's "non-standard verification" track record is sparse by design—the standard theory has passed innumerable tests and crushed most anomalies. That's exactly why this pillar matters: these predictions are **orthogonal** to the usual EM playbook and **falsifiable**

with existing tools. Neutral means the positives and negatives sum to zero—no net monopole. Spin a neutral, non-magnetic rotor and align its circulation with the global caustic plane. The model predicts a tiny, orientation-gated mechanical response: right spin + right facing → push; wrong facing (null tilt) → true zero; opposite facing or spin-flip → pull. With $\varepsilon > 0$, the half-cycles aligned with $+n$ are weighted slightly more than the opposite half-cycles, so the cycle-average picks up a small odd term $\propto \varepsilon \cdot \sigma$ (push/zero/pull). This fingerprint isn't in standard EM and is falsifiable with existing tools; if absent, we publish a tight upper bound and move on. The real value comes later as we cross-link this channel with other pillars in the practical branches.

Cross-link value (right now, not someday)

The biggest value shows up when we cross-link this orientation-gated EM with the other pillars and aim it straight at active programs and standards. That's how we turn the idea into knobs people already use—charge it, ship it, measure it, or steer it. **Five live "branches" to name-drop (and why they care):**

1. **Power & devices (EM × mechanics): auto-alignment became a standard.**
   Qi2 wireless charging literally bakes in **magnetic alignment** so phones snap to the right **facing** for efficiency/speed. That's our rule in consumer hardware: right facing → it works; wrong facing → it stinks. Cross-link: predict when "almost right" wastes heat and how to shape the nulls. Wireless Power Consortium+1

2. **Ultra-sensitive rigs (EM × precision mechanics): neutral rotors are ready.**
   Levitated nanoparticles now spin in vacuum at MHz–GHz and act as **torque/force sensors**. That's a turnkey platform to run our **push / zero / pull** test with spin-flip lock-in. Cross-link: spec the geometry from the mechanics pillar; we bring the orientation gates. Nature+1

3. **Backbone networks (EM × materials & comms): facing drifts are measurable.**
   Long-haul fiber suffers **polarization-mode dispersion** when the glass's preferred axes wander with heat and stress. Standards and tutorials already define how to test/mitigate it; we add an **angle-map** way to forecast the nulls. ITU+1

4. **Earth imaging (EM × sensing): polarimetry is mainstream and scaling up.**
   Polarimetric SAR literally toggles HH/HV/VV to make features **appear or vanish** by **orientation**; NISAR just launched with multi-pol modes. Cross-link: publish "orientation invisibility" predictions (where scenes drop out) and validate against NISAR passes. NASA Science+1

5. **Space weather (EM × environment): the sky rotates your facing.**
   Faraday rotation in the ionosphere twists polarization; ops teams already train on it and NASA just mapped gaps to upgrade models. Cross-link: a controller that keeps "facing" right in real time and kills fades. NWS Training Portal+1

Cross-Doc Rules & Dependencies
• No new dimensional scales beyond S_0 (loop-action constant).

• Use 'torsion constant' and 'shear constant' terminology; numeric values live in Base/Calibration.
• This pillar inherits locks from Base Calibration; no retune here.
• Out-arrows keep traceability: Narrative → Math Walk-Through → Math Appendix → Calibration → Extensions.

Inputs → Outputs (Schematic)

[diagram] Inputs: {S_0, locks, torsion/shear constant names} → Outputs: {Maxwell-limit recovery; EM source/field mapping; testable corrections}.

Where This Pillar Sits in VMS

Prereqs: void propagation, loop closure, and the main Math Appendix operator definitions. Electromagnetism provides the bridge from geometric descriptors (curvature-flux $\mathcal{K}$, oriented loop density $\mathbf{\Omega}$) to observed fields (E,B), and hands forward quantitative targets to Calibration and Predictions for spectroscopy and field-law tests.

Non-Goals / No New Knobs

We do not introduce new dimensional constants or retune base locks. We do not replace classical EM in its validated domain; we recover it as a limit and only propose tests where controlled deviations could appear within tolerances.

Maxwell-Limit Recovery Summary

Define pillar-local potentials $\Phi[\mathcal{K},\mathbf{\Omega}]$, $A[\mathcal{K},\mathbf{\Omega}]$, linear in the mapped geometric fields under coarse-graining. Set $E := -\nabla\Phi - \partial A/\partial t$ and $B := \nabla\times A$. Build source densities (ρ,J) from orientation/topology so that continuity ($\partial\rho/\partial t + \nabla\cdot J = 0$) holds away from defects. Under weak curvature and slow variation, E and B satisfy the Maxwell set with coefficients matched by calibration (ε_0, μ_0).
Out-of-Scope (this pillar):
Nonlinear optics (χ^2/χ^3), strong-field QED (Schwinger), magnetized plasma microphysics, and device/material deep dives (these live in branches or the Thermodynamics pillar).

What's New vs. Classical

• Source genesis: charge/current arise from orientation/topology of void loops (not postulated entities).
• Controlled corrections: torsion/shear enter as bounded, testable departures from the Maxwell limit.
• Ratio-first operations: when in-domain anchors are ultra-precise (e.g., hydrogen lines), prefer ratio-anchored estimates for operational use; retain cross-domain calibrated figures for audit.

Calibration capsule (targets & ratios)

The Calibration doc defines numeric gates (constants and spectroscopy). Example anchors include CODATA-2022 α and R∞, and NIST ASD Balmer Hα/Hβ, with explicit air↔vacuum handling. A worked example demonstrates predicting Hβ from Hα via the model line ratio r=20/27.

Documents in this Package

→ Electromagnetism_Math_Walkthrough
→ Electromagnetism_Math_Appendix
→ Electromagnetism_Calibration
→ Electromagnetism_Extensions_Predictions_Tests

This doc zeros in on what's new to measure: **orientation-gated effects** with crisp falsification. It anchors numbers to **CODATA-2022** and **NIST ASD** then uses real-world orientation lanes—**ionospheric Faraday rotation**, **SAR polarimetry (HH/VV/HV/VH)**, and **fiber PMD**—to define acceptance gates. The non-standard piece is a **neutral-rotor lab test** for the **push / zero / pull** triad and **spin-flip sign**, with pre-registered **3σ** calls and a **ratio-first vs calibrated** comparison to flag any divergence.

Air ↔ vacuum wavelengths (2-paragraph note)

Why this matters & how to do it right.
When you compare line lists or model outputs to lab/astro data, say explicitly whether numbers are in **vacuum** or **standard air**. In vacuum the wavelength λ_{vac} is tied to the wavenumber; in air the wavelength shortens by the refractive index n:

$$\lambda_{air} = \frac{\lambda_{vac}}{n} \quad \Rightarrow \quad \lambda_{vac} = n\,\lambda_{air}.$$

The NIST Atomic Spectra Database (ASD) converts with the **Peck–Reeder (1972)** "standard air" formula across **185–1700 nm** (15 °C, 101 325 Pa, 0.033% CO_2) and even calls out the boundary quirk near 200 nm (e.g., **200.0648 nm vacuum → 200.0000 nm air**). If you need real conditions (not "standard air"), use a **Ciddor-based** index (temperature, pressure, humidity, CO_2) or the **NIST Engineering Metrology Toolbox** calculator. Always state which model you used and the inputs. emtoolbox.nist.gov+3NIST+3NIST+3

Policy for this pillar.
Unless required otherwise, convert **everything to vacuum** before fitting/plotting, or report **both** with the model + inputs. Record: (i) conversion model (**Peck–Reeder** vs **Ciddor 1996**), (ii) environmental inputs (T, P, RH, CO_2), (iii) tool/version (e.g., *NIST EMT air-index calculator*). Note that ASD warns **air-wavelength uncertainties don't include the air↔vac conversion uncertainty**—log that separately. Be extra explicit if your bands straddle the **~200 nm** air/vac boundary used by ASD.

Constants registry (link + stamp)

Use the **CODATA 2022** recommended values from NIST; stamp this in the doc header:
"Constants: CODATA-2022 (NIST SP 961, May 2024); portal: physics.nist.gov/constants (accessed Sep 22, 2025)."
Primary sources: the **NIST constants portal** and the **CODATA-2022 wall chart/wallet card**; background and citation summary in the 2025 RMP review. NIST+2NIST+2

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