

VMS Electromagnetic Laws

A concise set of VMS-first laws for electromagnetism. Each law states its value, minimal math, and practical use. Classical recovery is shown as a limit (bridge).

Locked Conventions (apply everywhere)

- Display-area: $A_d = \pi r^2$ (projected disk), not $4\pi r^2$.
- Unit bridge: α bridges to SI Coulomb-style forms; e.g., $\alpha = 4/\epsilon_0 \Rightarrow E = Q/(4\pi \epsilon_0 r^2)$ when needed.
- Slowness/index: $n(x, \lambda)$ encodes medium response (closure/route shadow).
- Acceptance locks: import one dimensional scale $S_0 = \hbar$; μ_0, ϵ_0, c used only as unit locks (no tunables).

Part I — Core VMS Laws (Foundational)

L0 — Conventions

Statement: Use A_d and α ; avoid flux language; set the bridge explicitly when presenting SI forms.

How it's not classical: Classical optics starts from fields + Gauss/flux with $4\pi r^2$ areas.

Classical coverage: Meta-rule; not a numerical prediction.

L1 — Closure Conservation (inverse-square)

Statement: Stationary closure Q spreads over display-area A_d , giving $1/r^2$ strength.

Core math: $E_{\text{VMS}}(r) \propto \alpha \cdot Q / (\pi r^2)$

How it's not classical: No Gauss-sphere flux postulate; $1/r^2$ comes from projected area, not spherical flux.

Classical coverage: Matches classical magnitudes when $\alpha = 4/\epsilon_0$.

L2 — No Sideways Pile-Up (boundary continuity)

Statement: Tangential transport across boundaries is continuous; determines angles and amplitudes.

Core math: $n_1 \sin\theta_1 = n_2 \sin\theta_2$ (angles)

How it's not classical: Derived as a transport rule, not via Fermat or Maxwell BCs.

Classical coverage: Angles/amplitudes agree with classical results.

L3 — Route-Phase Superposition (interference)

Statement: Coherent routes add with phase set by closure comparisons; knob is path difference ΔL .

Core math: $\Delta\phi = (2\pi/\lambda) \Delta L$; bright: $\Delta L = m\lambda$; dark: $\Delta L = (m+\frac{1}{2})\lambda$

How it's not classical: Phase meaning is route-closure comparison rather than field axiom.

Classical coverage: Fringes identical to classical.

L4 — Eikonal & Rays

Statement: Write $U = A e^{i k_0 S}$; rays follow ∇S ; transport fixes A .

Core math: $|\nabla S|^2 = n^2$; $2 \nabla S \cdot \nabla A + A \nabla^2 S = 0$

How it's not classical: Assigns VMS meaning to n (closure/"slowness" budget).

Classical coverage: Same ray paths as classical eikonal theory.

L5 — Polarization Projection

Statement: Polarizer drains closure \perp to its axis; surviving field is the projection (Malus).

Core math: $I_{\text{out}} = I_{\text{in}} \cos^2 \Delta$

How it's not classical: Mechanism is closure drain, not field boundary components.

Classical coverage: Malus law unchanged.

L6 — Diffraction-Fourier Law

Statement: Finite A_d (pupil) \Rightarrow Fourier weighting; PSF/MTF from aperture transform.

Core math: $\theta_R \approx 1.22 \lambda/D$; $f_c = D/(\lambda f)$

How it's not classical: Framed via display-area/routes; math matches Fourier diffraction.

Classical coverage: Airy, OTF/MTF identical.

L7 — Étendue / Brightness Invariance

Statement: Paraxial invariants for route cones are conserved in passive systems.

Core math: $q = n\theta$; $H = x q$; $G = n^2 A \Omega = \text{const}$

How it's not classical: Motivated by route packing rather than radiance postulate.

Classical coverage: Same invariance as classical radiometry.

L8 — Dispersion & Achromats

Statement: $n(\lambda)$ varies with color; two-glass pair cancels first-order axial color.

Core math: $\varphi_1 + \varphi_2 = \varphi^*$; $\varphi_1/V_1 + \varphi_2/V_2 = 0$

How it's not classical: Interpretation of $n(\lambda)$ differs; design equations are the same.

Classical coverage: Same achromat conditions as classical.

L9 — DOF-Diffraction Trade

Statement: Defocus blur shrinks with $f/\#$; diffraction grows with $f/\#$; pick the crossover.

Core math: $c_{\text{defocus}} \propto 1/(f/\#)$, $r_{\text{diff}} \propto (f/\#)$

How it's not classical: Route-cone view adds geometric intuition; same outcome.

Classical coverage: Same trade curves as classical.

L10 — Interferometric Fringe Law

Statement: Path change is counted directly by fringes in 2-pass.

Core math: $\Delta L = m \lambda / 2$

How it's not classical: Treated as route metrology rather than field-only.

Classical coverage: Identical to classical interferometry.

L11 — Maxwell-Limit Reduction

Statement: With SI locks and smooth fields, VMS reduces to Maxwell's equations.

Core math: $F = dA$; $dF = 0$; $d \star F = J$

How it's not classical: Classical starts at Maxwell; VMS reduces to it as a limit.

Classical coverage: By construction, same equations.

L12 — Measurement-Domain Law

Statement: Use Jones/eikonal when phase matters; use Stokes/Mueller when intensities add.

How it's not classical: Framed as a modeling-domain law inside VMS, not a separate theory.

Classical coverage: Same practice as classical optics.

Part II — Extended Mass-Coupled Laws (New Value Propositions)

L-M1 — Mass-Coupled Slowness of “Vacuum”

Statement: Nearby mass perturbs slowness n used by routes; unify delay and bending under OPL.

Minimal form:

$$n(\mathbf{x}, \lambda) = 1 + \eta_0 \cdot \varphi(\mathbf{x}) + \eta_1(\lambda) \cdot \varphi(\mathbf{x}) \quad \text{where } \varphi \equiv \Phi/c^2$$

Immediate use:

- Delay: $\Delta t(\lambda) = (1/c) \int (n-1) ds$
- Bending: $\theta(\lambda) \approx \int \nabla_{\perp} n ds$

Classical limit: $\eta_0 = \eta_1 = 0$ (EM vacuum); GR corresponds to achromatic $\eta_0 \neq 0, \eta_1 = 0$.

L-M2 — Mass-Flow Non-Reciprocity (One-Way Phase Bias)

Statement: Mass currents bias counter-propagating phases in vacuum loops.

Minimal loop form:

$$\Delta\varphi_{\text{NR}}(\lambda) = \zeta(\lambda) \cdot (2\pi/(\lambda c)) \cdot \hat{n} \cdot \int (\boldsymbol{\Omega}_m(\mathbf{r}) \times \mathbf{r}) d\mathbf{A}$$

Immediate use:

- Additive bias in ring gyros: total phase = Sagnac + $\Delta\varphi_{\text{NR}}$
- Model $\zeta(\lambda)$ as a fitted coefficient vs rotor geometry/speed

Classical limit: $\zeta = 0$ (no mass-flow term).

L-M3 — Cavity Mode Pulling by Static Mass

Statement: Nearby mass shifts effective optical length in vacuum cavities.

Minimal form:

$$L_{\text{eff}}(\lambda) = \int n(\mathbf{x}, \lambda) ds \quad \Rightarrow \quad \delta f/f \approx - \langle n - 1 \rangle_L = -\eta_0 \langle \varphi \rangle_L - \eta_1(\lambda) \langle \varphi \rangle_L$$

Immediate use:

- Predict frequency drift sign/magnitude when mass approaches a cavity

- Treat $\langle n-1 \rangle$ as an environmental term in clock/comb models

Classical limit: $\eta_0 = \eta_1 = 0$ (no pull beyond mechanics/thermal).

L-M4 — Mass-Dependent Chromatic Lensing

Statement: Deflection carries a weak λ -dependence via $n(\mathbf{x}, \lambda)$.

Minimal thin-deflector form:

$$\alpha(\lambda) \approx \nabla_{\perp} \int (n - 1) dz = [\eta_0 + \eta_1(\lambda)] \nabla_{\perp} \int \phi dz$$

Immediate use:

- Add achromatic/chromatic split to lensing kernels; fit $\eta_0, \eta_1(\lambda)$ jointly with mass maps
- Propagate to time-delay: $\Delta t(\lambda)$ picks up the same parameters via OPL

Classical limit: $\eta_1(\lambda) = 0$ (achromatic); $\eta_0 = 0$ restores EM vacuum.

L-G1 — Closure-Limited Focusing (Route-Capacity Inequality)

Statement: Independent of diffraction, route/closure budgets cap peak concentration for a passive pupil.

Minimal bound (paraxial):

$$I_{\max} \leq K \cdot (A/\lambda^2) \cdot S(NA)$$

Immediate use:

- Ceiling check: compare predicted PSF peaks against the closure bound; expect plateau if exceeded
- Guide apodizer/stop choices to approach the bound realistically

Classical limit: matches the diffraction-limited scaling when $K \cdot S(NA)$ equals the Airy core constant; any extra saturation reflects the VMS cap.

Drop-In Forms (for modeling tools)

Rays/OPL:

$$OPL(\lambda) = \int n(\mathbf{x}, \lambda) ds; \quad t(\lambda) = (1/c) OPL(\lambda); \quad \text{ray tilt} \propto \nabla n(\mathbf{x}, \lambda)$$

Interferometer phase:

$$\Delta\phi(\lambda) = (2\pi/\lambda) \int (n - 1) ds + \Delta\phi_{NR}(\lambda)$$

Cavity frequency:

$\delta f/f = - \langle n - 1 \rangle$ over the cavity length

Lensing kernel:

$\alpha(\lambda) \propto \nabla \perp \int (n - 1) dz$ with $(n - 1) = \eta_0 \varphi + \eta_1(\lambda) \varphi$

Parameter Legend

- $\varphi = \Phi/c^2$: dimensionless gravitational potential along routes
- η_0 : small achromatic coupling to φ (dimensionless)
- $\eta_1(\lambda)$: small chromatic coupling to φ (dimensionless, weak λ -dependence)
- $\zeta(\lambda)$: small coupling for mass-flow non-reciprocity (dimensionless)
- A : pupil clear area; NA : numerical aperture; $K, S(NA)$: geometry factors
- α : unit bridge to recover SI Coulomb-style forms when desired

Classical / GR Limits (for comparison)

- EM vacuum: $\eta_0 = \eta_1 = \zeta = 0 \rightarrow n = 1$; no mass-coupled effects in vacuum.
- GR lensing/delay: achromatic effective term only $\rightarrow \eta_0 \neq 0, \eta_1 = 0, \zeta = 0$.
- Diffraction only: closure bound reduces to standard Airy scaling when $K \cdot S(NA)$ matches the Airy constant.

VMS Electromagnetism — Additional Considerations (Concise List of 40)

Claim — how it is not classical — measurement signature to look for.

1) Mass-coupled refraction in vacuum

Claim: Nearby mass changes local slowness $n(x)$, bending rays and adding phase delay.

Not classical: Maxwell vacuum has $n=1$; GR bending is achromatic with fixed coefficient.

Signature: Tiny extra bending and phase delay vs mass proximity; check for weak λ -dependence.

2) Mass-dependent chromatic lensing

Claim: Lensing by mass has a small λ -dependence through $n(\lambda)$.

Not classical: GR lensing in vacuum is achromatic (plasma aside).

Signature: Differential deflection/time delay vs wavelength after de-plasma correction.

3) Mass-induced polarization rotation / birefringence

Claim: Torsion/shear budgets near mass impose a feeble polarization bias.

Not classical: GR predicts negligible gravitational birefringence; EM vacuum has none.

Signature: Sub- μ rad rotation in crossed-polarizer nulls near dense/moving mass.

4) Boundary mass-loading shifts interference

Claim: Slit/mask mass distribution perturbs route closure \rightarrow material-dependent phase.

Not classical: Classical two-slit depends on geometry and optical n , not substrate density.

Signature: Fringe center shift/envelope skew with identical coatings but different substrates.

5) Mass-flow optical drag (non-reciprocity)

Claim: Moving/rotating mass induces a one-way phase bias in vacuum loops.

Not classical: Sagnac is rotation-only; Fizeau requires flowing refractive media.

Signature: Non-reciprocal phase vs rotor speed in a ring after isolating vibrations.

6) Vacuum index map around compact masses

Claim: $n(x)=1+\delta n(\Phi)$ tracks gravitational potential.

Not classical: EM vacuum has no index; GR uses metric (achromatic).

Signature: Shapiro-like delay in evacuated paths grazing a mass; compare coefficient/sign.

7) Mass-gradient tweaks to Fresnel amplitudes

Claim: Tangential continuity across mass-graded boundaries yields tiny amplitude corrections.

Not classical: Fresnel set purely by EM boundary conditions.

Signature: Angle-dependent ellipsometric micro-offsets with identical optical stacks on different density substrates.

8) Closure-limited upper bound on focusing

Claim: Geometric closure budget caps peak concentration beyond diffraction.

Not classical: Classical limits are diffraction + material nonlinearities only.

Signature: PSF core saturates vs apodizations at high NA beyond diffraction expectations.

9) Mass-proximity waveguide dispersion shift

Claim: Guided modes pick extra phase near dense supports even in vacuum regions.

Not classical: Mode indices depend only on dielectric profile.

Signature: Ring-resonator FSR/frequency shift over heavy vs light pedestals (same dielectrics).

10) Achromat residual tied to areal mass

Claim: First-order achromat holds; a secondary residual scales with element mass.

Not classical: Secondary spectrum classically from higher-order dispersion only.

Signature: Two identical-glass doublets with different densities show repeatable color focus offsets.

11) Étendue with mass gradients

Claim: Étendue invariant holds or gains minute corrections under mass gradients.

Not classical: Invariant assumed regardless of mass proximity in classical radiometry.

Signature: Throughput vs cone angle near dense blocks shows strict null or tiny deviations.

12) Polarization-dependent gravitational phase (null)

Claim: Either strict null (consistent with GR) or tiny split from VMS budgets.

Not classical: GR and EM vacuum: null.

Signature: Dual-pol interferometer skimming mass; improved upper bounds even if null.

13) Mass-tuned speckle statistics

Claim: Route-ensemble weighting alters speckle contrast in mass-graded cavities.

Not classical: Speckle set by coherence/aperture/scatterers only.

Signature: Contrast changes when introducing/removing dense inserts at fixed optics.

14) Near-field evanescent coupling vs mass

Claim: Evanescent decay picks up a small mass-dependent term via closure budgets.

Not classical: Decay set by dielectric gaps only.

Signature: Prism-coupler attenuation length shifts with a dense body just outside the optical near field.

15) Parametric phase modulation by oscillating mass

Claim: Oscillating mass modulates closure → route phase/frequency sidebands.

Not classical: No EM-only coupling in vacuum.

Signature: PDH cavity sidebands at the mass drive after acoustic/thermal isolation.

16) Mass-gradient Goos-Hänchen/Imbert-Fedorov shifts in vacuum

Claim: Lateral/vertical beam shifts appear without dielectric interfaces, biased by nearby mass.

Not classical: GH/IF classically require interfaces and material n .

Signature: Tiny centroid shifts when a beam grazes a dense slab in vacuum.

17) Ambient mass-jitter phase-noise floor

Claim: Random mass motion adds route-phase jitter.

Not classical: EM alone: no such floor; noise is technical/quantum.

Signature: Interferometer noise rises with controlled mass motion independent of acoustics.

18) Cavity mode pulling by static mass

Claim: Nearby mass shifts optical length in vacuum and pulls cavity modes.

Not classical: EM vacuum gives none; GR effect is too tiny for lab scale.

Signature: Stable cavity frequency drifts with a dense block approach (distance law, achromaticity test).

19) Chromatic knife-edge diffraction vs edge mass

Claim: Fringe phase offset depends on edge mass even with identical geometry/optical n .

Not classical: Classical depends on geometry and optical constants only.

Signature: Offset difference for identical edges on heavy vs light mounts/coatings.

20) Mass-biased Sagnac offset

Claim: Static mass asymmetry biases loop phase (non-reciprocity) in addition to rotation.

Not classical: Sagnac offset is rotation-only classically.

Signature: Phase bias that flips with swapping heavy/light segments around the loop.

21) Vacuum birefringence near mass (null expectation)

Claim: VMS allows tiny polarization splitting near dense mass.

Not classical: Classical/QED vacuum needs strong B fields; near mass alone is null.

Signature: Sub- μ rad differential phase/rotation near dense rotor/block; set upper bounds.

22) Path-closure hysteresis

Claim: Route closure shows slow re-settling after mass relocation (memory).

Not classical: EM has no memory once geometry resets.

Signature: Phase lag/relaxation after moving a mass out/in with reproducible time constant.

23) Spontaneous-emission tweak near mass

Claim: Emitter lifetime shifts slightly with mass proximity via closure budgets.

Not classical: Purcell shifts need dielectric/EM structures, not neutral mass.

Signature: Narrowline emitter lifetime changes with a dense object behind a vacuum gap.

24) Vacuum impedance Z_0 micro-shift in potential wells

Claim: Z_0 acquires a minute Φ -dependence.

Not classical: Free-space impedance is constant in classical EM.

Signature: Free-space antenna S-parameters drift near dense object in anechoic chamber.

25) Waveguide cutoff drift from external mass

Claim: Hollow-guide cutoff f_c shifts with nearby dense rings (external mass).

Not classical: Cutoff set by geometry and ϵ , μ only.

Signature: Measure f_c shift when hugging guide with heavy vs light rings.

26) Pulse-front tilt from mass proximity

Claim: Route-phase skew induces spatiotemporal PFT changes.

Not classical: PFT classically from angular dispersion only.

Signature: Streak camera observes PFT change as mass approaches the path.

27) Mode-dependent chromatic redshift in cavity

Claim: Different TEM modes/ λ feel slightly different mass-induced pulls.

Not classical: GR redshift is achromatic; EM vacuum has none.

Signature: Mode/ λ -dependent frequency offsets beyond dispersion/thermal models.

28) Grating non-reciprocity via mount mass

Claim: ± 1 diffraction orders imbalance tied to mount density.

Not classical: Classically symmetric if geometry/optic constants match.

Signature: Order imbalance flips when swapping heavy/light mounts.

29) Achromat secondary tied to areal mass (repeat of #10, imaging focus)

Claim: Residual chromatic focus depends on element mass beyond glass dispersion only.

Not classical: Classical: higher-order dispersion only.

Signature: Color focus offset repeats with density change, same glass and shape.

30) Étendue stress test in mass gradients (repeat/extension of #11)

Claim: Either strict invariance or minute corrections under mass gradients.

Not classical: Classical invariant regardless of mass proximity.

Signature: Throughput vs cone angle near dense block: confirm null or bound deviations.

31) Mass-dependent speckle statistics (extension of #13)

Claim: Route weighting in multi-pass cavities alters speckle contrast.

Not classical: Classical speckle from aperture/coherence/scatter only.

Signature: Contrast shifts when dense insert is moved among passes.

32) Near-field evanescent coupling vs mass (extension of #14)

Claim: Decay length picks up mass term via closure budgets.

Not classical: Classical decay set by dielectric gap only.

Signature: Coupling length changes with dense body just outside near field.

33) Parametric sidebands from oscillating mass (extension of #15)

Claim: Mass motion imposes sidebands through route modulation in vacuum.

Not classical: No EM-only drive in vacuum.

Signature: Sidebands at drive frequency in PDH after ruling out acoustics.

34) Handedness bias near rotating mass

Claim: RCP/LCP accumulate slightly different phases near a flywheel.

Not classical: No such effect in EM vacuum; GR frame dragging is negligible in lab.

Signature: Differential phase shift between RCP/LCP vs rotor speed.

35) Fiber delay vs altitude/potential beyond GR coefficient

Claim: Chromatic tweak to gravitational delay in fiber links.

Not classical: GR gives fixed achromatic coefficient; chromatic residuals are dispersion.

Signature: Dual- λ time transfer over height baseline shows residual beyond fiber dispersion model.

36) Aperture-stop mass loading on PSF/MTF

Claim: Stop mass biases route cone beyond geometry alone.

Not classical: Classically only geometry matters (given rigid mechanics).

Signature: Marginal PSF/MTF change at wide aperture with heavy vs light stops.

37) E-B partition bias near mass

Claim: Plane-wave E/B phase/ratio slightly skewed by mass proximity.

Not classical: Free-space E/B ratio fixed in classical EM.

Signature: Calibrated E and B probes detect tiny phase/ratio drift near dense object.

38) RF-optical cross-phase via shared closure

Claim: RF and optical interferometers co-vary through common route budgets.

Not classical: Domains independent in classical EM.

Signature: Correlated phase drifts in colocated RF/optical loops when mass moves.

39) Mass-graded thin-film Fresnel micro-offsets

Claim: Fresnel Ψ , Δ pick up angle-dependent micro-offsets with substrate density.

Not classical: Classical Fresnel depends only on optical n, k of layers.

Signature: Ellipsometry shows tiny, systematic offsets for heavy vs light substrates.

40) Null-boosting checks (global)

Claim: Many above should be strict nulls under EM+GR; strong bounds still carve parameter space.

Not classical: Classically nulls are expected; any non-zero is new.

Signature: Publish tight upper limits even if no detection; parameterize (η_0, η_1, ζ) .