# An Open Letter to the Ultrafast-Photonics, Condensed-Matter, and Quantum-Optics Communities: Manifestly Hermitian Optomagnetic Floquet–Zeeman Gauge Dynamics, Non-Hermitian Band Topology, and Exact Quantum-Optical Bounds

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**Abstract**

This document is written as an open letter to researchers in ultrafast optomagnetism, non-Hermitian topological photonics, ultracold quantum gases, and quantum optics. Earlier working notes on optical Zeeman torque, non-Hermitian photonic crystals, negative effective mass, bosonic quantum optics, and stochastic moduli-space photon dynamics [1–7] identified promising experimental regimes—most notably spin–orbit-assisted magnetic Floquet engineering and non-Hermitian bound states in the continuum—while containing critical sign, Hermiticity, random-matrix, differential-geometric, and integral-identity errors that alter quantitative predictions by factors of two or reverse stability criteria.

Here we establish a fully consistent theoretical synthesis across these seven works. First, we derive the manifestly Hermitian second-order Magnus–Floquet optomagnetic Hamiltonian, correcting an anti-Hermitian commutator prefactor, the Magnus expansion sign, and an exact factor-of-two underestimate in the magnetic-to-electric competition ratio $R_{\mathrm{mix}}$, while restoring the static $\mathcal{O}(A^2, \Omega^0)$ Peierls band renormalization and demonstrating that linearly polarized traveling plane waves already maximize photon-drag optomagnetic torque. Second, we repair the Marchenko–Pastur operator-entanglement entropy bound on non-Hermitian photonic crystals for general aspect ratio $Q = M^2/N^2 > 1$, correct Vakhitov–Kolokolov Morse-index and electrostrictive couplings, and resolve the regularity-structure dimensionality obstruction on Teichmüller space. Third, we unify negative effective mass stability, dark-photon vortex equations, polylogarithmic Bose integrals, and Englert–Greenberger–Yasin interferometric visibility bounds, concluding with targeted experimental tests in twisted $MoTe_2$ and $MnBi_2Te_4$.

What follows is a technical statement of the corrected optomagnetic, non-Hermitian, and quantum-optical equations, together with a direct request that ultrafast-photonics and condensed-matter groups evaluate their observable signatures. The discussion is organized in six points.

**(1) Manifestly Hermitian Magnus–Floquet optomagnetic Hamiltonian and traveling-wave torque.** For a two-band spin–orbit-coupled Bloch system $\hat{H}_0(\mathbf{k}) = \mathbf{d}(\mathbf{k}) \cdot \boldsymbol{\sigma}$ driven at off-resonant frequency $\Omega$ by $\mathbf{A}(t) = \mathrm{Re}[\mathbf{A}_0 e^{-i\Omega t}]$ and $\mathbf{B}_{\mathrm{opt}}(t) = \mathrm{Re}[\mathbf{B}_0 e^{-i\Omega t}]$, earlier derivations [1] exhibited three algebraic inconsistencies: (i) minimal coupling $(\hat{\mathbf{p}} + e\mathbf{A})^2$ for electron charge $q = -e$ takes $+\mu_B \boldsymbol{\sigma} \cdot \mathbf{B}_{\mathrm{opt}}$ in Eq. (1) of [1] but flipped to $-\mu_B \boldsymbol{\sigma} \cdot \mathbf{B}_{\mathrm{opt}}$ in Eq. (6); (ii) the high-frequency Magnus expansion carried an inverted sign $+\frac{1}{\hbar\Omega}[\hat{H}_{+1}, \hat{H}_{-1}]$; and (iii) Eq. (15) of [1] wrote $[\hat{\mathbf{v}} \cdot \mathbf{A}_0, \hat{\mathbf{v}} \cdot \mathbf{A}_0^*] = +\frac{4i}{\hbar^2} \sum \varepsilon_{abc} (\partial_{k_i} d_a)(\partial_{k_j} d_b) \, \mathrm{Im}[A_{0,i} A_{0,j}^*] \sigma_c$, whose right-hand side is *purely anti-Hermitian* because $\mathrm{Im}[A_{0,i} A_{0,j}^*]$ is real.

Computing the exact time-ordered Magnus series for $\hat{H}(t) = \hat{H}_0 + \hat{H}_{+1} e^{-i\Omega t} + \hat{H}_{-1} e^{+i\Omega t}$ and evaluating $[\sigma_a, \sigma_b] = 2i\varepsilon_{abc}\sigma_c$ against the antisymmetric dyadic $A_{0,i} A_{0,j}^* - A_{0,j} A_{0,i}^* = 2i \, \mathrm{Im}[A_{0,i} A_{0,j}^*]$ yields $i \cdot (2i) = -2$ (real Hermitian!) and removes the spurious factor of two:

$$\hat{H}_F^{(1)} = -\frac{1}{\hbar\Omega} \big[\hat{H}_{+1}, \hat{H}_{-1}\big], \qquad \hat{H}_{+1} = \frac{1}{2} \left(e\hat{\mathbf{v}} \cdot \mathbf{A}_0 - \mu_B \boldsymbol{\sigma} \cdot \mathbf{B}_0\right), \quad \hat{H}_{-1} = \hat{H}_{+1}^\dagger, \tag{1}$$

$$\big[\hat{\mathbf{v}} \cdot \mathbf{A}_0, \, \hat{\mathbf{v}} \cdot \mathbf{A}_0^*\big] = -\frac{2}{\hbar^2} \sum_{a,b,c} \sum_{i,j} \varepsilon_{abc} (\partial_{k_i} d_a)(\partial_{k_j} d_b) \, \mathrm{Im}\big[A_{0,i} A_{0,j}^*\big] \sigma_c, \tag{2}$$

Three physical consequences follow immediately from Eqs. (1)–(2):

- **Exact factor-of-two enhancement of $R_{\mathrm{mix}}$ and static diamagnetic dressing.** Because Eq. (15) of [1] inflated the purely electric denominator by a factor of two, the true optical-Zeeman-to-electric competition ratio $R^{\mathrm{true}}_{\mathrm{mix}}(\mathbf{k})$ is *twice* Eq. (16) of [1]. Simultaneously, expanding $\hat{H}_0(\mathbf{k}+\frac{e}{\hbar}\mathbf{A}(t))$ to second order in $\mathbf{A}$ retains the static $\mathcal{O}(A^2,\Omega^0)$ Peierls diamagnetic renormalization $\hat{H}^{(0)}_{\mathrm{dia}}$, which exceeds the $\mathcal{O}(A^2/\Omega)$ Magnus shift by $\hbar\Omega/W \gg 1$ in narrow-band moiré systems:

$$R^{\mathrm{true}}_{\mathrm{mix}}(\mathbf{k}) = 2\,\eta_Z^{(\mathrm{spin})}\,\frac{\left\|\sum_{i,b}\mathrm{Im}[A_{0,i}B^*_{0,b}]\,\partial_{k_i}\mathbf{d}\times\hat{e}_b\right\|}{\left\|\sum_{i,j}\mathrm{Im}[A_{0,i}A^*_{0,j}]\,\partial_{k_i}\mathbf{d}\times\partial_{k_j}\mathbf{d}\right\|}, \qquad \hat{H}^{(0)}_{\mathrm{dia}} = \frac{e^2}{4\hbar^2}(\partial_{k_i}\partial_{k_j}\hat{H}_0)\,\mathrm{Re}\big[A_{0,i}A^*_{0,j}\big], \tag{3}$$

- **Linearly polarized traveling-wave photon-drag torque.** Contrary to the remark following Eq. (16) of [1], generating nonzero mixed optomagnetic torque $\mathrm{Im}[A_{0,i}B^*_{0,b}]\neq 0$ does *not* require elliptical polarization or non-paraxial beams. In any linearly polarized *traveling* plane wave, $\mathbf{E} = -\partial_t\mathbf{A} = i\Omega\mathbf{A}$ and $\mathbf{B}_0 = \frac{i\Omega}{c}\hat{z}\times\mathbf{A}_0$, so $\mathbf{A}_0$ and $\mathbf{B}_0$ are automatically $\pi/2$ out of phase: $\mathrm{Im}[A_{0,i}B^*_{0,b}] = -\frac{1}{\Omega}\,\mathrm{Re}[E_{0,i}B^*_{0,b}]$ is proportional to the time-averaged Poynting momentum flux and vanishes only in standing waves. Note also that Assouline and Capua [8] reported theoretical Landau–Lifshitz–Gilbert calculations rather than experiments, complementing recent experimental twisted-$MoTe_2$ observations [9]. Finally, the axion term in Eq. (27) of [1] requires explicit $\hbar$ restoration and consistent Levi-Civita sign $\varepsilon^{0123}=+1$.

**(2) Non-Hermitian photonic crystals, Marchenko–Pastur entropy, and moduli-space obstructions.** In [2], non-Hermitian line-gap Chern projectors, dual Jordan chains at exceptional points, Friedrich–Wintgen bound states in the continuum, and open Heisenberg–Langevin Bogoliubov squeezing are cleanly formulated (noting that Ref. [5] of [2] belongs to Kawabata, Shiozaki, Ueda, and Sato [10] rather than Gong et al.). However, four mathematical defects in [2, 6] require rigorous repair:

- **Aspect-ratio dependence of the Marchenko–Pastur operator entropy.** For an $N^2\times M^2$ bipartite Choi matrix with aspect ratio $Q = M^2/N^2 \geq 1$, [2] correctly retains $Q$ in the linear entropy $\langle S_L\rangle = 1-\frac{1+Q}{N^2Q}$ (Eq. 37), yet drops $Q$ in the von Neumann entropy $\langle S_V\rangle = \ln(N^2)-\frac{1}{2}$. Integrating $\int\lambda\ln\lambda\,d\mu_{\mathrm{MP}}(\lambda)$ over the exact Marchenko–Pastur density yields $\mathbb{E}[w\ln w] = \frac{1}{2Q}$, giving the exact Page–Marchenko–Pastur expectation:

$$\langle S_V(U_{\partial Y})\rangle = \ln(N^2) - \frac{1}{2Q}, \qquad \langle S_L(U_{\partial Y})\rangle = 1-\frac{1+Q}{N^2Q}, \qquad Q=\frac{M^2}{N^2}\geq 1, \tag{4}$$

  Using $\ln(N^2)-\frac{1}{2}$ as a hard barrier cutoff in Eq. (38) of [2] placed typical Haar-random unitaries strictly inside the $+\infty$ forbidden wall for every $Q>1$.

- **Electrostriction, Morse index, and parametric pump accounting.** In Eq. (14) of [2], an extra dummy index $l$ tripled the coupling; physically, linear piezoelectricity shifts polariton dispersion linearly in $\mathbf{E}$, whereas nonlocal cubic Kerr feedback $\Gamma_{\mathrm{piezo}}(K*|E|^2)E$ arises from quadratic electrostriction. Around fundamental solitons, Vakhitov–Kolokolov stability requires Morse index $n(L_+)=1$ (one negative eigenvalue, not zero positive eigenvalues [2]). In the Floquet squeezing channel (Eq. 20 of [2]), rotating-wave expansion of $\cos(\Omega t)$ introduces a factor of $\frac{1}{2}$, and pair creation draws energy from the external classical pump rather than "harvesting" vacuum energy.

- **Failure of KPZ regularity structures on $\mathcal{M}_g$ and inverted dephasing exponent.** Both [2] and [6] introduce Hairer's regularity structures for a KPZ-type equation $\partial_t h = \Delta_{\mathrm{WP}}h + |\nabla_{\mathrm{WP}}h|^2 + \xi$ on Teichmüller space $\mathcal{T}_g$. Because space-time white-noise KPZ is subcritical only in spatial dimension $d=1$ (critical at $d=2$, non-renormalizably supercritical for $d\geq 3$), while $\dim_{\mathbb{R}}\mathcal{T}_g = 6g-6\geq 6$ for $g\geq 2$, KPZ is strictly outside the domain of regularity structures. Moreover, Fenchel–Nielsen vector fields $\{H_{l_i}, H_{\tau_i}\}$ are not mapping-class-group invariant and do not descend to $\mathcal{M}_g$, Teichmüller flow preserves Masur–Veech measure on $\mathcal{Q}^1\mathcal{M}_g$ rather than Weil–Petersson measure on $\mathcal{M}_g$, and $\mathrm{Vol}_{\mathrm{WP}}(\mathcal{M}_g)$ is constant rather than growing linearly with time [6]. Finally, Eq. (39) of [2] inverted the sign of the dephasing exponential, predicting $1-V\to 0$ as transit time $\tau_{\mathrm{cross}}\to\infty$; consistent decoherence gives Eq. (5).

**(3) Negative effective mass stability, Bose polylogarithms, and quantum-optical visibility duality.** Unifying the condensed-matter and quantum-optical analyses in [3–5, 7] removes five persistent textbook and algebraic discrepancies:

- **Negative effective mass, Weyl's law, and dark-photon vortices [3].** In [3], the Gel'fand–Levitan–Marchenko kernel reconstructs the Schrödinger potential $V(x) = -2\frac{d}{dx}K(x,x)$, not the SUSY

superpotential $W(x)$; Vakhitov–Kolokolov stability for focusing $m^* > 0, g < 0$ is $dP/d\mu < 0$ ( $dP/d(-\mu) > 0$), and acoustic stability depends on $\mathrm{sgn}(g/m^*) > 0$ rather than $\mathrm{sgn}(m^*)$ alone. In Weyl's law on bounded domains, the $\mathcal{O}(\sqrt{E})$ boundary term is proportional to perimeter $\mp\frac{\mathrm{Length}(\partial M)}{4\pi}\sqrt{E}$, not dimensionless integrated geodesic curvature $\int_{\partial M}\kappa\,ds$. For the Abelian-Higgs dark-photon vortex, restoring conventions yields $m_X = \sqrt{2}\,g_X v$, scalar term $-\frac{\lambda}{2}(f^2 - v^2)f$, and gauge ODE $a'' - \frac{1}{r}a' + 2g_X^2 f^2(1-a) = 0$ (correcting the sign that forced oscillatory Bessel $J_1$ solutions incompatible with $a(\infty) = 1$), coupled to visible flux $\Phi_{\mathrm{vis}} = -\chi\Phi_X$. Furthermore, negative effective mass is already well established experimentally in spin–orbit-coupled BECs [11] and photonic mesh lattices [12], and the opening remark in [3] of a bound solar twin star ("Nemesis") is ruled out by WISE and Gaia DR3.

- **Bose polylogarithms, Fock categories, and historical attribution [4, 7].** In [4], $\mathrm{Li}_1(e^{-x}) = \sum_{n\geq 1} e^{-nx}/n$ was confused with the divisor Lambert series, and the $e^x$ numerator was dropped from the Bose integral $\int_0^\infty x^m e^x (e^x-1)^{-2}\,dx = \Gamma(m+1)\zeta(m)$; the exact corrected identities are given in Eq. (6). Likewise, $\prod_i (1-x_i)^{-1} = \sum_{n\geq 0} h_n(\{x_i\})$ sums over single-row complete homogeneous polynomials $h_n$ (not all partitions $\lambda$), $\mathrm{Sym}(H)$ is infinite-dimensional and does not map $\mathbf{FdHilb} \to \mathbf{FdHilb}$, connected spider-fusion diagrams have cardinality 1 (not $\binom{A+N-1}{N}$), and bosonic Hong–Ou–Mandel two-photon interference requires bosonic LOv/ZW calculus rather than single-qubit Hadamard ZX spiders (noting historically that Bose [13] maximized cell-occupation counts $p_r^s$ rather than stars-and-bars counts). Separately, in [7], Maxwell's 1846 oval paper studied multifocal Cartesian ovals $mr_1 + nr_2 = c$ rather than polar Fourier curves, Saturn's ring stability requires epicyclic $\kappa^2 = \Phi''(r_0) + 3\omega^2$ (the naive bracket $\omega^2 - \Phi'(r_0)/r_0$ vanishes identically on circular orbits), and the displacement current appeared in Maxwell's 1861–1865 papers prior to the 1873 *Treatise*.
- **Visibility–distinguishability duality and delayed-choice erasers [5].** Double-slit decoherence [5] obeys exact Englert–Greenberger–Yasin duality $V^2 + D^2 \leq 1$ (Eq. 5) without requiring conscious observers. In delayed-choice quantum erasers, projecting the ancilla onto $|D_\pm\rangle = \frac{1}{\sqrt{2}}(|D_1\rangle \pm |D_2\rangle)$ does not alter $\langle D_2|D_1\rangle = 0$ or restore fringes in the unconditional total pattern (which would violate no-signaling); complementary fringes and anti-fringes emerge strictly under coincidence post-selection.

$$V = V_0 \exp\!\big(-\Gamma_{\mathrm{moduli}}\tau_{\mathrm{cross}}\big) \implies 1 - V = 1 - V_0 e^{-\Gamma_{\mathrm{moduli}}\tau_{\mathrm{cross}}}, \qquad V^2 + D^2 \leq 1, \tag{5}$$

$$\int_0^\infty \frac{x^m}{(e^x-1)^2}\,dx = \Gamma(m+1)\big(\zeta(m) - \zeta(m+1)\big) \quad (m \geq 2), \qquad \sum_{n=1}^{\infty}\frac{1}{e^{nx}-1} = \sum_{k=1}^{\infty} d(k) e^{-kx}. \tag{6}$$

**(4) Summary of corrected relations and experimental targets.** Table 1 consolidates the repaired equations across [1–7] alongside direct experimental observables.

**Table 1.** Summary of corrected mathematical expressions and physical mechanisms across [1–7].

| Domain / Source | Earlier Expression / Defect | Corrected Formulation & Experimental Signature |
|---|---|---|
| Optomagnetic Floquet [1] | Anti-Hermitian $+4i/\hbar^2$; $R_{\mathrm{mix}}$ halved; $+\frac{1}{\hbar\Omega}[H_{+1}, H_{-1}]$ | Hermitian $-\frac{2}{\hbar^2}$; $R_{\mathrm{mix}}^{\mathrm{true}} = 2R_{\mathrm{eq16}}$; $-\frac{1}{\hbar\Omega}[H_{+1}, H_{-1}] + \hat{H}^{(0)}_{\mathrm{dia}}$; traveling-wave torque |
| Non-Hermitian Crystals [2] | $\langle S_V\rangle = \ln N^2 - \frac{1}{2}$; $n(L_+) = 0$; $1 - V \propto e^{-\Gamma\tau}$ | $\langle S_V\rangle = \ln N^2 - \frac{1}{2Q}$; $n(L_+) = 1$; $V = V_0 e^{-\Gamma\tau_{\mathrm{cross}}}$; electrostriction & pump power |
| Moduli SPDEs [2, 6] | KPZ on $\mathcal{T}_g$ ($\dim \geq 6$); non-invariant FN flow on $\mathcal{M}_g$ | Supercritical KPZ excluded; intrinsic WP geodesic/Brownian motion on $T^1\mathcal{M}_g$ away from cusps |
| Negative Mass [3] | Weyl $\sqrt{E}\int\kappa\,ds$; vortex $-2g_X^2 f^2(1-a)$; Nemesis | Perimeter $\mp\frac{L(\partial M)}{4\pi}\sqrt{E}$; $+2g_X^2 f^2(1-a)$ with $m_X = \sqrt{2}g_X v$; $\mathrm{sgn}(g/m^*) > 0$ |
| Bose & Quantum Optics [4, 5] | $\mathrm{Li}_1 = \sum(e^{nx}-1)^{-1}$; $\Gamma(m+1)\zeta(m)$ without $e^x$ | Divisor Lambert series; $\Gamma(m+1)(\zeta(m) - \zeta(m+1))$; LOv calculus; post-selected eraser |

**(5) Request to Ultrafast-Photonics and Quantum-Optics Groups.** We request two focused theoretical and experimental evaluations:

- **Theoretical evaluation.** We ask Floquet-topology and random-matrix theorists to benchmark Eq. (3) against full tight-binding Floquet–Bloch simulations including the $\mathcal{O}(A^2, \Omega^0)$ Peierls dressing and to verify the $Q$-dependent Page–Marchenko–Pastur transition in non-Hermitian photonic boundary ensembles (Eq. 4).
- **Experimental feasibility.** We ask ultrafast tr-ARPES and Kerr-rotation groups working on twisted $MoTe_2$, $MnBi_2Te_4$, and Bi:YIG photonic crystals to test the traveling-wave linearly polarized photon-

drag optomagnetic torque (Eqs. 2–3) via pump-helicity versus Poynting-reversal protocols at mid-infrared and telecom wavelengths.

**(6) Conclusion and forward work.** Restoring exact Hermiticity, Magnus signs, random-matrix aspect-ratio scaling, soliton Morse indices, and Bose integral identities eliminates all internal contradictions across [1–7] and isolates the traveling-wave optomagnetic ratio $R_{\mathrm{mix}}^{\mathrm{true}}$ and $Q$-dependent boundary entropy as clean, falsifiable targets for ultrafast condensed-matter photonics.

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