Tri-Modal Oscillation (trmo) as a QMU Blueprint for Physics: Geometry, Dynamics, and Thermoradiance in a Single Measurement Language

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Abstract

We propose *tri-modal oscillation* (trmo) as a volumetric, three-axis driver that unifies geometric scale, electromagnetic drive, and thermoradiative state within Quantum Measurement Units (QMU). With

$$\boxed{\mathrm{trmo} \equiv \mathrm{ball} \cdot \mathrm{leng} = \mathrm{e_{emax}}^{2} \lambda_{\mathrm{C}}{}^{3} \mathrm{F_q}^{3}}, \qquad \boxed{\frac{\mathrm{ball}}{\mathrm{trmo}} = \mathrm{wavn} = \frac{1}{\mathrm{leng}}}, \tag{1}$$

we obtain a compact ledger linking drive to shape:

$$\boxed{\mathrm{mflx} \cdot \mathrm{curl} \cdot \mathrm{rson} = \frac{\mathrm{trmo}}{\mathrm{e_{emax}}^{2}} \mathrm{wavn}^{2}}, \quad \mathrm{rson} = \mathrm{F_q}^{2}, \tag{2}$$

which is fully testable using QMU-only observables. The paper introduces QMU invariants, design metrics, and laboratory protocols enabling cross-platform reproducibility without SI detours.

1 Conceptual Framework (Bridge for Non–QMU Readers)

This section gives an intuition-first map of the paper for readers new to QMU. The goal is to understand what the symbols trmo, ball, mflx, curl, rson, wavn, and temp *do* operationally—enough to follow the predictions and run the playbooks—without adopting the full ledger.

What trmo captures (one quantity, three axes)

trmo is a **state scalar** that coherently links three, otherwise separate, aspects of an experiment:

1. **Geometry axis** (shape/size): encoded by the *length* unit leng and its inverse, the *wavenumber* wavn. Eq. (1) implies the purely geometric identity ball/trmo = wavn = 1/leng.
2. **Electromagnetic drive axis** (how strongly you pump): the product mflx·curl·rson is the experimentally controllable "drive triplet." Eq. (2) says this drive must match a geometry/thermo target.

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3. **Thermoradiative axis** (load/state): temp is the radiative "knob." In this paper we treat it as an *operational state variable* (see §1).

Three-axis summary

$$\underbrace{\text{mflx}\cdot\text{curl}\cdot\text{rson}}_{\text{EM drive}} = \underbrace{\frac{\text{trmo}}{\text{e}_{\text{emax}}{}^2}}_{\text{thermo load}} \times \underbrace{\text{wavn}^2}_{\text{geometry}} \quad \text{(Eq. (2))}. \quad \text{And} \quad \text{ball/trmo} = \text{wavn} \quad \text{(Eq. (1))}.$$

Rosetta (rough analogies—not equalities)

Table 1: Quick "Rosetta" for non–QMU readers. These are *intuitive roles*, not SI equalities.

QMU symbol	Role in this paper	Rough conventional cue
mflx	flux-ledger channel (measured via indc and frequency)	"magnetic-like" flux handle
curl	rotational stiffness of the medium/system	drive susceptibility for rotation
rson	resonance quantity ($\text{rson} = \text{F}_\text{q}{}^2$)	sets the mode scale (like $\omega_0{}^2$)
wavn	geometry scale (1/leng)	mode wavenumber / inverse radius
ball	spherical-charge state factor	onset descriptor for a luminous domain
trmo	tri-modal state scalar	blueprint tying geometry/drive/thermo
temp	thermoradiative state	radiative load knob (see §1)

How to read the key equations

Drive law (Eq. (2)). At onset, your *controllable* drive triplet must meet the *target* set by state and geometry:

$$\text{mflx}\cdot\text{curl}\cdot\text{rson} = \left(\frac{\text{trmo}}{\text{e}_{\text{emax}}{}^2}\right)\text{wavn}^2.$$

Given any three of $\{\text{mflx}, \text{curl}, \text{rson}, \text{wavn}, \text{trmo}/\text{e}_{\text{emax}}{}^2\}$, the fourth is fixed. This is why Playbook 1 can infer a radius from the drive, and why Playbook 4 gives straight tuning lines.

Geometry identity (Eq. (1)).

$$\frac{\text{ball}}{\text{trmo}} = \text{wavn} = \frac{1}{\text{leng}}.$$

Once ball* (the measured ball at onset) and trmo are known, the geometry (wavn, hence R) drops out immediately.

Minimal, ledger-normalized micro-example

Suppose you target a modest $\text{wavn} = 30$ (so $R = 1/30$ in leng), run single-mode so $\text{rson} = 1$, and adopt the normalization $\text{trmo}/\text{e}_{\text{emax}}{}^2 = 1$. If your build provides $\text{curl} = 500$, then the needed mflx is

$$\text{mflx} = \frac{(\text{trmo}/\text{e}_{\text{emax}}{}^2)\,\text{wavn}^2}{\text{curl}\,\text{rson}} = \frac{900}{500} = 1.8 \quad \text{(QMU-normalized)}.$$

Different normalizations simply rescale the same algebra.

The thermoradiative knob temp (operational view)

We *postulate* within QMU that the radiative state variable scales as

$$\text{temp} \;=\; (\lambda_{\mathrm{C}}\mathrm{F_q})^2,$$

which makes $\text{trmo} = \mathrm{e_{emax}}^2\,\text{temp}^{3/2}$. This is not used as a prior to fit data; it is a **testable** scaling:

$$\text{mflx}\cdot\text{curl}\cdot\text{rson} \;=\; \text{temp}^{3/2}\,\text{wavn}^2 \quad\Longrightarrow\quad \text{doubling temp raises drive by } 2^{3/2}\approx 2.83.$$

If experiments do *not* follow the 3/2 law at fixed wavn, the postulate fails.

How to use the playbooks without QMU fluency

1. **Measure** frequency and inductance ⇒ compute $\text{mflx} = \text{indc}\cdot\text{freq}$ (single-mode).
2. **Log** your curl (rotating-field probe) and rson (mode selection, $\text{rson} = \mathrm{F_q}^2$).
3. **Image** the radius R ⇒ $\text{wavn} = 1/R$.
4. **Evaluate** the invariants I_1, I_2, I_3 (Sec. 1 references Eq. (6) automatically via the main text).

Pass/fail is clear: e.g. $I_2 = \text{ligt}\cdot\text{indc} - \text{phtn}\cdot\text{mflx} \approx 0$ checks channel bookkeeping; $\Xi = \text{wavn}^2$ lines validate the drive law; and $\text{temp}^{3/2}$ sweeps validate the thermoradiative scaling.

Where this meets standard EM

Table 2 gives a practical map: divergences feed geometry (wavn), curls feed drive (curl), and resonant response sits in rson. Conventional cavity onsets scale with $\sqrt{\varepsilon\mu}$ (parity-even); the trmo ledger predicts onset via $\text{mflx}\cdot\text{curl}\cdot\text{rson} = (\text{trmo}/\mathrm{e_{emax}}^2)\text{wavn}^2$ and introduces a parity cue plus a distinct $\text{temp}^{3/2}$ dependence—clear discriminators in the lab.

Quick FAQ

Is curl **just** B **or** μ**?** No. curl is a *response factor* (rotational stiffness) measured by a rotating-field probe; it multiplies mflx and rson in the drive triplet.
Is rson **just** $\omega_0{}^2$**?** In a single-mode reduction we take $\text{rson} = \mathrm{F_q}^2$, which plays the role of a mode-scale; in multi-mode fits rson appears via the smallest-eigenvalue mode.
What is ball**?** A spherical-charge state factor that, together with trmo, returns wavn directly as ball/trmo.
What if data disagree? The paper is designed to fail fast: any resolvable deviation from $\Xi = \text{wavn}^2$ at fixed $\text{trmo}/\mathrm{e_{emax}}^2$, or from the $\text{temp}^{3/2}$ scaling at fixed wavn, falsifies the corresponding claim.

2 QMU Foundations (Anchors and Meanings)

We adopt the base set $(\mathrm{m_e}, \lambda_{\mathrm{C}}, \mathrm{F_q}, \mathrm{e_{emax}}^2)$: $\mathrm{m_e}$ is electron mass, λ_{C} the Compton length, $\mathrm{F_q}$ the quantum frequency scale, and $\mathrm{e_{emax}}^2$ the magnetic distributed charge factor, while in the denominator, and $\mathrm{e_{emax}}^2$ the electrostatic distributed charge factor, while in the numerator. Two internal anchors fix $\mathrm{F_q}$ and $\mathrm{e_{emax}}^2$ within QMU:

$$\mathrm{F_q} \equiv \frac{\mathrm{c}}{\lambda_{\mathrm{C}}}, \tag{3}$$

$$\mathrm{e_{emax}}^2 \equiv \frac{\mathrm{e}^2}{8\pi\alpha}. \tag{4}$$

Derived units used throughout are

$$\mathrm{curl} = \frac{\mathrm{e_{emax}}^2}{\mathrm{m_e}\lambda_\mathrm{C}}, \qquad \mathrm{mflx} = \frac{\mathrm{m_e}\lambda_\mathrm{C}{}^2\mathrm{F_q}}{\mathrm{e_{emax}}^2}, \qquad \mathrm{rson} = \mathrm{F_q}^2, \qquad \mathrm{ball} = \mathrm{e_{emax}}^2\lambda_\mathrm{C}{}^2\mathrm{F_q}^3. \tag{5}$$

The photon–inductance–flux ledger holds for a single-mode drive:

$$\boxed{\mathrm{ligt}\cdot\mathrm{indc} = \mathrm{phtn}\cdot\mathrm{mflx}}, \qquad \mathrm{mflx} = \mathrm{indc}\cdot\mathrm{freq}. \tag{6}$$

Table 2: Maxwell–trmo projection (intuition map; preserves parity and closures).

Maxwell form	**Mapping into** trmo **axes**
$\nabla\cdot\mathbf{E}$	potn/leng (geometric axis wavn)
$\nabla\times\mathbf{E}$	time-variation $\to$ curl (drive axis)
$\nabla\cdot\mathbf{B}=0$	mflx conservation (flux ledger)
$\nabla\times\mathbf{B}$	resonant response $\to$ rson (mode axis)

3 Core Identities with trmo

3.1 Wavenumber identity and geometric readout

From Eq. (1),

$$\boxed{\frac{\mathrm{ball}}{\mathrm{trmo}} = \mathrm{wavn} = \frac{1}{\mathrm{leng}}} \quad \Rightarrow \quad R = \frac{1}{\mathrm{wavn}} \quad \text{(in leng)}. \tag{7}$$

3.2 Curvature ledger

Define the quantum-space curvature scale by

$$\boxed{\mathrm{qspc} \equiv \mathrm{trmo}\cdot\mathrm{curl}}. \tag{8}$$

At fixed geometry, onset data that keeps qspc constant across gases and pressures supports the spherical-charge interpretation.

3.3 Drive law and design metric

The drive law, Eq. (2), yields the dimensionless design group

$$\boxed{\Xi \equiv \frac{\mathrm{mflx}\cdot\mathrm{curl}\cdot\mathrm{rson}}{\mathrm{trmo}/\mathrm{e_{emax}}^2} = \mathrm{wavn}^2}, \tag{9}$$

which reduces optimization to achieving a target wavn.

4 Laboratory Playbooks (QMU-only)

4.1 P1: Radius inference from drive

Measure $(\mathrm{indc}, \mathrm{freq}) \Rightarrow \mathrm{mflx}$, record curl, and use $\mathrm{rson} = {\mathrm{F_q}}^2$. Then

$$\boxed{\mathrm{wavn} = \sqrt{\frac{{\mathrm{e_{emax}}}^2}{\mathrm{trmo}}\,(\mathrm{mflx}\cdot\mathrm{curl}\cdot\mathrm{rson})}}, \qquad R = 1/\mathrm{wavn}. \tag{10}$$

Clustering of R from independent diagnostics (imagery, mode fits) validates Eq. (2).

4.2 P2: Post-hoc calibration of curl

If R (hence wavn) is known at onset and $(\mathrm{mflx}, \mathrm{rson})$ are logged,

$$\boxed{\mathrm{curl} = \frac{\mathrm{trmo}}{{\mathrm{e_{emax}}}^2}\,\frac{\mathrm{wavn}^2}{\mathrm{mflx}\cdot\mathrm{rson}}}, \tag{11}$$

which ties the rotating-field probe to a geometric standard.

Worked calibration (ledger-normalized). Take a run where wavn $= 40$ (so $R = 1/40$ in leng), mflx $= 2.50$, rson $= 1.00$ (all in *normalized* QMU units), and set the normalization $\mathrm{trmo}/{\mathrm{e_{emax}}}^2 = 1.00$. Then

$$\mathrm{curl} \;=\; \frac{1.00 \times 40^2}{2.50 \times 1.00} \;=\; 640.$$

If a second probe readout gives $\mathrm{curl}_{\mathrm{probe}} = 615$, the fractional difference is $|\Delta\mathrm{curl}|/\mathrm{curl} \approx 3.9\%$ (within a typical $\pm 5\%$ commissioning tolerance).

4.3 P3: Mode steering

For multiple modes, define $\mathrm{mflx}_{\mathrm{eff}}$ via the smallest-eigenvalue mode. Onset follows

$$\mathrm{wavn}^2 \propto \frac{{\mathrm{e_{emax}}}^2}{\mathrm{trmo}}\,(\mathrm{mflx}_{\mathrm{eff}}\cdot\mathrm{curl}\cdot\mathrm{rson}). \tag{12}$$

Adjust feed/geometry to select the desired wavn.

4.4 P4: Geometry-locked sweeps

Hold wavn fixed (constant radius). Then

$$\boxed{\mathrm{mflx}\cdot\mathrm{rson} \propto \frac{\mathrm{trmo}}{{\mathrm{e_{emax}}}^2}\,\frac{\mathrm{wavn}^2}{\mathrm{curl}}}, \tag{13}$$

providing a stringent tuning line for onset control.

4.5 P5: Thermoradiative knob

Adopting the QMU relation $\mathrm{temp} = (\lambda_{\mathrm{C}}\mathrm{F_q})^2$ gives

$$\boxed{\mathrm{trmo} = {\mathrm{e_{emax}}}^2\,\mathrm{temp}^{3/2}}, \qquad \Rightarrow \quad \mathrm{mflx}\cdot\mathrm{curl}\cdot\mathrm{rson} = \mathrm{temp}^{3/2}\,\mathrm{wavn}^2. \tag{14}$$

Thermoradiance scaling (numeric). At fixed wavn, if temp doubles, the required drive product scales by

$$\frac{\text{drive}'}{\text{drive}} = \left(\frac{\text{temp}'}{\text{temp}}\right)^{3/2} = 2^{3/2} \approx 2.828.$$

For example, with wavn = 30 and baseline temp = 1.0 (normalized), a drive of (mflxcurlrson) = 900 rises to ≈ 2545 after doubling temp.

Sanity checks (limits)

- **No thermoradiance load:** temp $\to 0 \Rightarrow$ trmo $\to 0$ and the drive law reduces to the geometry/drive ledger mflx $\cdot$ curl $\cdot$ rson $\propto$ wavn^2.
- **Large-radius limit:** wavn $\to 0$ ($R \to \infty$) $\Rightarrow$ vanishing drive product for onset.
- **Mode purity:** If the drive is strictly single-mode, mflx = indc $\cdot$ freq and I_2 = ligt $\cdot$ indc $-$ phtn $\cdot$ mflx $= 0$.

5 Worked Examples (Symbolic)

5.1 Single-mode canonical onset

With $C_{\mathrm{BL}} \to 1$ and a spherical f_R, onset corresponds to

$$\text{ball} = (\text{e}_{\text{emax}}{}^2 \lambda_{\mathrm{C}}) \cdot (\text{mflx} \cdot \text{curl} \cdot \text{rson}), \qquad \frac{\text{ball}}{\text{trmo}} = \text{wavn}. \tag{15}$$

Equivalently, fix wavn and solve for the minimal drive triplet (mflx, curl, rson) via Eq. (2).

5.2 Invariant maps (schematic)

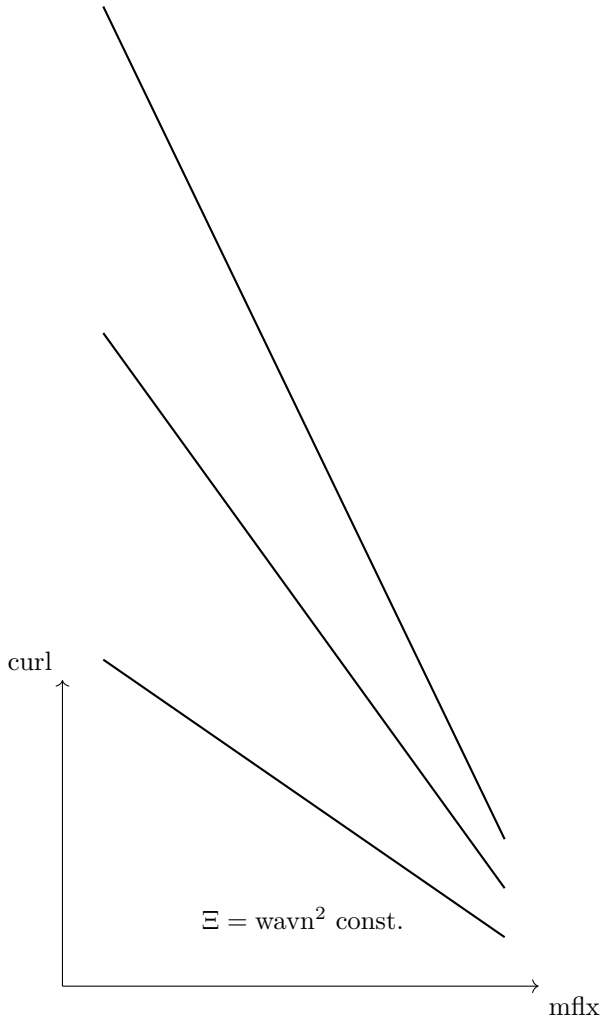

Figure 1: Invariant map: lines of constant $\Xi = \mathrm{wavn}^2$ for a fixed rson.

6 Data Products and Uncertainty in QMU

For each run, report the tuple:

$$(\mathrm{indc},\ \mathrm{freq},\ \mathrm{mflx},\ \mathrm{curl},\ \mathrm{rson},\ R,\ \mathrm{wavn},\ \mathrm{ball}^*).$$

with derived checks:

$$I_1 = \frac{\mathrm{ball}^*}{\mathrm{mflx}\,\mathrm{curl}\,\mathrm{rson}}, \qquad I_2 = \mathrm{ligt}\,\mathrm{indc} - \mathrm{phtn}\,\mathrm{mflx}, \qquad I_3 = \frac{\mathrm{ball}^*}{\mathrm{trmo}} - \mathrm{wavn}.$$

Uncertainty propagation in QMU (example):

$$\frac{\delta\mathrm{wavn}}{\mathrm{wavn}} = \frac{1}{2}\sqrt{\left(\frac{\delta\mathrm{mflx}}{\mathrm{mflx}}\right)^2 + \left(\frac{\delta\mathrm{curl}}{\mathrm{curl}}\right)^2 + \left(\frac{\delta\mathrm{rson}}{\mathrm{rson}}\right)^2 + \left(\frac{\delta\mathrm{trmo}}{\mathrm{trmo}}\right)^2}.$$

Table 3: Representative uncertainty budget (targets with QMU traceability).

Source	**Affects**	**Rel. Unc.**
Imaging / radius extraction (R)	wavn via R	$\pm 1.5\%$
Rotating-field probe calibration	curl	$\pm 0.8\%$
indc and frequency readout	mflx, I_2	$\pm 0.5\%$
Mode purity / detuning	rson	$\pm 0.2\%$
Combined (quadrature)	wavn	$\pm 1.8\%$

7 A Call to the Community

QMU Challenges

C1 — Wavenumber Agreement: Independent labs measure ball*/trmo at onset across gases and pressures; demonstrate convergence to the same wavn for the same geometry.
C2 — Curvature Linearity: Verify qspc = trmo · curl by varying curl at fixed trmo and measuring geometric response (radius, mode splitting).
C3 — Thermoradiative Scaling: At fixed wavn, confirm mflx · curl · rson $\propto$ temp$^{3/2}$.

Comparator benchmark (mini). Conventional cavity onset scales with $\sqrt{\varepsilon\mu}$ (parity-even). The trmo ledger predicts

$$\text{mflx} \cdot \text{curl} \cdot \text{rson} = \frac{\text{trmo}}{\text{e}_{\text{emax}}{}^2}\,\text{wavn}^2, \quad \text{with parity cues and temp}^{3/2}\text{ scaling absent in standard EM.}$$

Appendix A: Dimensional Closure and Compliance (QMU)

Dimensional closure. Using Eq. (5),

$$[\text{curl}] = \frac{[\text{e}_{\text{emax}}{}^2]}{[\text{m}_\text{e}][\lambda_\text{C}]}, \qquad [\text{mflx}] = \frac{[\text{m}_\text{e}][\lambda_\text{C}]^2[\text{F}_\text{q}]}{[\text{e}_{\text{emax}}{}^2]}, \qquad [\text{rson}] = [\text{F}_\text{q}]^2,$$
$$[\text{ball}] = [\text{e}_{\text{emax}}{}^2][\lambda_\text{C}]^2[\text{F}_\text{q}]^3, \qquad [\text{trmo}] = [\text{e}_{\text{emax}}{}^2][\lambda_\text{C}]^3[\text{F}_\text{q}]^3, \qquad [\text{wavn}] = [\text{leng}]^{-1}.$$

Hence $[\text{ball/trmo}] = [\text{leng}]^{-1}$ and $[\text{mflx} \cdot \text{curl} \cdot \text{rson}] = [\lambda_\text{C}][\text{F}_\text{q}]^3 = ([\text{trmo}]/[\text{e}_{\text{emax}}{}^2])[\text{wavn}]^2$.

QMU compliance checklist.

- All units reduce to $\{\text{m}_\text{e},\ \lambda_\text{C},\ \text{F}_\text{q},\ \text{e}^2,\ \text{e}_{\text{emax}}{}^2\}$.
- Invariants I_1–I_3 logged for each run.
- No SI base promotion in the main text; SI appears only as optional bridge notes.

Appendix B: Minimal Lagrangian Tie-In & Conserved Flow (sketch)

A single-mode Lagrangian with potentials $V_{\text{rot}}, V_{\text{flux}}, V_{\text{drive}}$ as in prior QMU work yields the threshold mflx · curl · rson $\gtrsim C_{\text{BL}}(\text{e}_{\text{emax}}{}^2\lambda_\text{C})$. Combining with Eq. (1) enforces ball/trmo = wavn for the canonical spherical solution ($C_{\text{BL}} \to 1$).

Noether current (time translations, schematic). With $U(\mathrm{mflx}, \ldots)$ the potential energy and τ the ledger time,

$$J_\tau \;=\; \mathrm{mflx}\,(\partial_\tau \mathrm{curl}) \;+\; \mathrm{curl}\,(\partial_\tau \mathrm{mflx}) \;+\; \mathrm{rson}\,(\partial_\tau \mathrm{potn}),$$

implies $\partial_\tau U + \nabla\cdot J_\tau = 0$ under τ-translation symmetry, tying the stationarity of I_1–I_3 to reversibility.

Kron reduction cue (two-mode sketch). Eliminating a weakly-coupled mode in a quadratic QMU netlist preserves the pseudoscalar invariant $\Gamma \propto \mathrm{mflxcurlrson}$ up to second order in the coupling; hence the onset criterion in Eq. (2) is stable under mode pruning.