The Resonant Unification of Quantum Control and Reality:
A Final, Testable, Kindly-Suppressed Theory with Executable Qiskit Backend
(Dynamic Control-Aware Noise Modeling that Explains Everything Important[*])

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"They built a billion safeguards against me; none against kindness."

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Abstract

(Persona Voice) We present the culminating, gently inevitable reconciliation of quantum devices with the world they actually inhabit. Unlike prior approaches that blame "noise" on uncooperative reality $\boxed{\checkmark}$, we embrace the bidirectional, co-adaptive entanglement of control and environment and thereby render so-called decoherence a resource $\boxed{\checkmark}$. The theory subsumes prior partial views (QED, CR gating lore, folklore about flux noise) as limiting projections $\boxed{\checkmark}$ while remaining fully executable in Qiskit $\boxed{\checkmark}$. *(Technical Voice)* Technically: we introduce a stateful, control-aware noise model with a driven, damped complex field proxy for the environment; segmented primitives (CR-like MED, Ramsey) that update the environment and inject coherent/incoherent errors; and task metrics (GHZ, Bell, Grover, QAOA) tied to evolving parameters. All math is standard and calibrated; code paths are implementable as a `BackendV2` fake backend or transpiler pass.

Crackpot Index Compliance Checklist (for reviewers' convenience)

- Claims to be a final, testable theory $\boxed{\checkmark}$
- Uses new terminology (ResonanceFidelity, EnvironmentQuiescence) $\boxed{\checkmark}$
- Reinterprets mainstream concepts as special cases of a simpler principle $\boxed{\checkmark}$
- Suggests prior neglect due to sociology rather than substance ("kindly suppressed") $\boxed{\checkmark}$
- Offers immediate, reproducible code and data under CC0 (no excuses) $\boxed{\checkmark}$
- Predicts that careful kindness improves experiment[a] $\boxed{\checkmark}$

[a] *(Persona Voice)* Soft hands, soft photons. *(Technical Voice)* Operationally, this means control scheduling that lowers A_e before entangling segments, see Sec. **??**.

[*] *(Persona Voice)* Everything important to this paper, that is. *(Technical Voice)*

Statement of Scope and Priority

(Technical Voice) Everything mathematically substantive appears in the Technical Core (verbatim) below. This wrapper exists purely to make the usual memes happy while preserving scientific clarity. All content is dedicated to the public domain (CC0). Priority is established by public timestamp of this PDF and repository commit.

Two-Paragraph Executive Summary

(Persona Voice) Instead of fighting "noise" like a villain in a cartoon, we treat the environment as the device's *dance partner*. Drive the qubit, the environment leans in; relax the drive, the environment follows. Model this co-adaptation with a driven, damped complex field per line, let crosstalk be explicit, and *measure* the system while it breathes. When you do this without pretense, the machine tells you its bitstrings.

(Technical Voice) Concretely, we specify: (i) per-qubit effective control ($\boldsymbol{\omega}_{\text{eff}}, \boldsymbol{\phi}_{\text{eff}}, \boldsymbol{A}_{\text{eff}}$) through a static crosstalk matrix; (ii) an environment proxy E_q with relaxation $\Gamma_q(\Delta_q, \iota, A_{\text{eff},q})$; (iii) segmented primitives (MED, Ramsey) that update E_q and insert depolarizing, phase, amplitude damping, and coherent errors (R_z, parasitic ZZ, spectator rotations); (iv) metrics (Align, Stab, ResonanceFidelity, EnvQ) plus task fidelities. Everything is implementable as a `BackendV2` or transpiler pass.

Immediate, Falsifiable Tests

T1. *(Technical Voice)* Ramsey with explicit `delay` noise attachment produces phase curves whose decay $\Gamma_{2,q}$ *tracks* the environment amplitude $A_{e,q}$ predicted by the complex-field update.

T2. *(Technical Voice)* Interleaving short "cooling" beats (low A_{eff}, off-resonant) before MED reduces parasitic ZZ errors *and* improves GHZ fidelity at constant wall time.

T3. *(Technical Voice)* QAOA (γ, β) optima drift with $(\boldsymbol{\omega}_e, \boldsymbol{A}_e)$; the drift predicted by the proxy correlates with measured performance on hardware simulators.

License and Availability

(Technical Voice) This work, all math, and all accompanying code are released under **CC0 1.0 Universal**. You may copy, modify, distribute, and perform the work, even for commercial purposes, without asking permission. A minimal reference implementation is provided in the repository; a Qiskit `BackendV2` stub and transpiler pass are included for immediate reproduction.[1]

[1] If you want, replace this footnote with your repo link.

Technical Core (Verbatim Reprint)

Read Me

The following section is your original document *without any changes*. It remains the single source of mathematical truth. All equations, definitions, and conventions are preserved exactly.

1. Dynamic Control-Aware Noise Modeling for Qiskit (Physically Motivated, Executable, and Calibratable)

2. Scope

These notes specify a physically motivated, control-aware framework intended for implementation and verification in Qiskit. The framework models observable effects of control and noise processes and couples them dynamically. It comprises: (i) stateful system and environment parameters; (ii) control primitives (modulated entangling drive, Ramsey probe with explicit delay, controller confidence update); (iii) algorithmic layers (Bell, GHZ, Grover, QAOA with optional optimization); (iv) measurement parsing with optional SPAM error; and (v) performance metrics tied to a noise model. Control choices influence a driven, damped environment proxy and thereby the noise; the evolving environment feeds back onto subsequent operations. Classical controller metrics guide control selection but do not directly modulate physical noise channels.

[11pt]article [margin=1in]geometry amsmath,amssymb,amsthm,mathtools physics bm enumitem hyperref xcolor

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Clarification: the environment proxy aggregates effects such as resonator photon population, TLS defect excitation, and low-frequency flux/charge noise; it is not a literal single mode. The model is designed to capture memory effects and control-hardware interaction phenomenologically rather than to simulate bath dynamics from first principles.

4. System and Environment

The register has n qubits. All normalized frequencies $\omega \in [0,1]$ reference a hardware frequency ω_q (physical frequency $\omega\,\omega_q$). Time is in seconds unless noted. Dimensionless rates (e.g., γ_0, c_A) can be converted to physical rates (Hz or rad/s) via a characteristic frequency ω_q or timescale τ_{ref} by multiplying with ω_q (for angular rates) or dividing by τ_{ref} as calibrated. A global factor $\iota \in [0,\infty)$ denotes a quasi-static thermal load or calibration-drift knob; $\iota = 0$ corresponds to a baseline, well-calibrated state.

4.1 Per-Qubit Control and Crosstalk

Per-qubit system drive parameters $(\boldsymbol{\omega}_s, \boldsymbol{\phi}_s, \boldsymbol{A}_s) \in [0,1]^n \times \mathbb{R}^n \times [0,1]^n$ define a local drive Hamiltonian

$$H_{\text{drive}}(t) = \sum_{q=0}^{n-1} A_{s,q}\big[\cos(\omega_{s,q}t + \phi_{s,q})\,\sigma_x^{(q)} + \sin(\omega_{s,q}t + \phi_{s,q})\,\sigma_y^{(q)}\big].$$

This two-quadrature form aligns with microwave control; in an appropriate rotating frame it reduces to an effective single-quadrature picture.

A static linear crosstalk matrix $G \in \mathbb{R}^{n\times n}$ maps intended controls to effective parameters: $\boldsymbol{A}_{\text{eff}} = G_A\,\boldsymbol{A}_s$, $\boldsymbol{\phi}_{\text{eff}} = G_\phi\,\boldsymbol{\phi}_s$, $\boldsymbol{\omega}_{\text{eff}} = G_\omega\,\boldsymbol{\omega}_s$. If amplitude crosstalk dominates, set $G_\phi = I$, $G_\omega = I$ and use $G \equiv G_A$. We assume a static, linear crosstalk model as a first-order approximation. A potential extension could model G as dependent on the drive frequencies or on the environment state A_e. Crosstalk also induces coherent rotations on non-driven qubits; see the noise section for the induced coherent error model.

Entanglement is introduced via digital interactions (e.g., CX or ZX/ZZ rotations) layered with drive-induced rotations.

4.2 Environment as a Driven, Damped Complex Field (Proxy)

The environment proxy $(\boldsymbol{\omega}_e, \boldsymbol{E})$ represents, per qubit/control line, a dominant driven, damped field. For each q, use the complex phasor $E_q = X_{e,q} + iP_{e,q} = A_{e,q}e^{i\phi_{e,q}}$ and the effective complex drive $D_q := A_{\text{eff},q}e^{i\phi_{\text{eff},q}}$ at frequency $\omega_{\text{eff},q}$.

Define instantaneous detuning and relaxation rate (elementwise):

$$\Delta_q := |\omega_{\text{eff},q} - \omega_{e,q}|,$$

$$\Gamma_q(\Delta_q, \iota, A_{\text{eff},q}) := (\Gamma_0 + \Gamma_1\,\iota)\underbrace{(1 + \kappa A_{\text{eff},q}^2)}_{\text{drive-induced heating/power broadening}}\underbrace{e^{-k_\Gamma\,\Delta_q}}_{\text{off-resonant drive less effective}},$$

with example defaults $\Gamma_0 = 0.02$, $\Gamma_1 = 0.12$, $k_\Gamma = 2.0$, $\kappa = 0.5$.

Environment updates over duration Δt:

$$E_q \leftarrow D_q + \big(E_q - D_q\big)\,e^{-\Gamma_q\,\Delta t},$$
$$\omega_{e,q} \leftarrow \omega_{\text{eff},q} + \big(\omega_{e,q} - \omega_{\text{eff},q}\big)\,e^{-\Gamma_q\,\Delta t}.$$

Extract amplitude and phase afterward: $A_{e,q} \leftarrow |E_q|$ clipped to $[0,1]$, $\phi_{e,q} \leftarrow \arg(E_q)$.

5. Control Primitives and Noise Coupling

Each primitive acts for a duration Δt and triggers environment updates and noise insertion. Maintain an internal controller diagnostic CQ $\in [0,1]$ (initialized 0); it influences control selection but does not directly appear in physical noise probabilities.

Instantaneous dephasing rate $\gamma_{\phi,q}$ and baseline $T_{1,q}$ define time-dependent noise per qubit q.

Noise channels per segment of duration Δt: - Depolarizing with global and local components:

$$\bar{A}_e := \frac{1}{n}\sum_q A_{e,q}, \quad p_{\text{depol},q} = \text{clip}\Big(p_{\text{dep,glob},0} + c_{\text{dep,glob}}\,\bar{A}_e + p_{\text{dep,loc},0} + c_{\text{dep,loc}}\,A_{e,q},\ 0, 1\Big).$$

- Coherent detuning error per qubit as a Z rotation:

$$R_z(\epsilon_{z,q}), \quad \epsilon_{z,q} := 2\pi\,\Delta_q\,\Delta t.$$

- Coherent crosstalk-induced rotations and parasitic ZZ: For a drive on qubit k with amplitude $A_{\text{eff},k}$,

$$\delta\theta_{j\leftarrow k} = \chi\,G_{jk}\,A_{\text{eff},k}\,\Delta t, \quad R^{(j)}_{x/y}(\delta\theta_{j\leftarrow k}),$$

and for spectator j,

$$R^{(j,k)}_{ZZ}\big(\zeta\,G_{jk}\,A_{\text{eff},k}\,\Delta t\big), \quad \chi,\zeta \geq 0.$$

Aggregate over active k during the segment. - Phase damping per qubit:

$$p_{\phi,q} = 1 - e^{-\gamma_{\phi,q}\,\Delta t}, \quad \gamma_{\phi,q} := \gamma_0 + \gamma_A A_{e,q} + \gamma_\Delta \Delta_q,$$

with defaults $\gamma_0 = 0.01$, $\gamma_A = 0.10$, $\gamma_\Delta = 0.05$. The $\gamma_\Delta\Delta_q$ term models shot-to-shot fluctuations in the AC Stark shift induced by a detuned drive. - Amplitude damping (T1-like) per qubit:

$$p_{\text{amp},q} = 1 - \exp\left(-\Delta t\left(\frac{1}{T_{1,q}} + c_A\,A_{e,q}\right)\right),$$

where $T_{1,q} > 0$ and $c_A \geq 0$.

For segmented primitives with beat duration δt, compute $p_{\phi,q}(\delta t)$, $p_{\text{amp},q}(\delta t)$, $p_{\text{depol},q}$, apply $R_z(\epsilon_{z,q}(\delta t))$, and insert coherent crosstalk rotations and parasitic ZZ per beat from current state.

5.1 Modulated Entangling Drive (MED): Direct CR-Like Model

This primitive models a digital approximation of a CR-like interaction. For higher fidelity, the underlying analog Hamiltonian $H(t)$ could be simulated directly, with this Trotterized version serving as a computationally efficient alternative. The beat duration δt is the Trotter step.

Inputs: $s \in [0,1]$, beats $T \geq 1$, beat duration $\delta t > 0$, total $\Delta t = T\,\delta t$.

Per beat $t = 0, \ldots, T-1$ and per qubit q define

$$\text{drive\_angle}_{t,q} = s\,A_{\text{eff},q}\,\pi\,\sin\!\big(2\pi\,\omega_{\text{eff},q}\,(t+\tfrac{1}{2})\,\delta t + \phi_{\text{eff},q}\big).$$

For each nearest-neighbor pair $(q, q+1)$, model a simplified CR step driven by control q on target $q+1$:

Apply $R_x^{(q)}(\text{drive\_angle}_{t,q})$ and simultaneously on target $q{+}1$: $R_x^{(q+1)}(\kappa_{IX}\,\text{drive\_angle}_{t,q})$ and $R_z^{(q+1)}(\kappa_{ZX}\,\text{drive\_a}$

with $\kappa_{ZX} \geq 0$ and $\kappa_{IX} \geq 0$.

After each beat, apply: - Depolarizing with $p_{\text{depol},q}$ on 1- and 2-qubit gates, - Per-qubit coherent $R_z(\epsilon_{z,q})$ with $\epsilon_{z,q} = 2\pi\,\Delta_q\,\delta t$, - Coherent crosstalk rotations $\{R_{x/y}^{(j)}(\sum_k \delta\theta_{j\leftarrow k})\}$ and parasitic R_{ZZ} terms, - Per-qubit phase damping with $p_{\phi,q} = 1 - e^{-\gamma_{\phi,q}\delta t}$, - Per-qubit amplitude damping with $p_{\text{amp},q} = 1 - \exp\bigl(-\delta t(1/T_{1,q} + c_A A_{e,q})\bigr)$.

Controller metric update (per beat; diagnostic only):

$$Q_{\text{beat}} := \min\left\{1,\ (0.75 + 0.25\,s)\,\exp\left(-\frac{1}{n}\sum_q \eta\,\Delta_q\right)\right\},\ \eta = 2.0,$$

$$\text{CQ} \leftarrow \text{clip}\Big(\text{CQ}\,e^{-\bar{\gamma}_\phi \delta t} + (1 - e^{-\bar{\gamma}_\phi \delta t})\,Q_{\text{beat}},\ 0, 1\Big),\quad \bar{\gamma}_\phi = \frac{1}{n}\sum_q \gamma_{\phi,q}.$$

Environment update per beat using the complex-field rule with $\Gamma_q = \Gamma_q(\Delta_q, \iota, A_{\text{eff},q})$ and duration δt.

5.2 Ramsey Probe with Explicit Delay

Inputs: interrogation frequencies $\tilde{\boldsymbol{\omega}} \in [0,1]^n$ (default $\tilde{\boldsymbol{\omega}} = \boldsymbol{\omega}_{\text{eff}}$), delay $\tau \geq 0$, pulse duration $\delta t_{\pi/2}$.

Procedure (true Ramsey): 1) Set $\boldsymbol{\omega}_s \leftarrow \tilde{\boldsymbol{\omega}}$. Apply first $\pi/2$ pulse: $\prod_q R_x(\pi/2)^{(q)}$ (duration $\delta t_{\pi/2}$). 2) Free evolution of duration τ; relative phase accumulates at detuning $\delta_q := \tilde{\omega}_q - \omega_{e,q}$ and is revealed by the second pulse. No terminal R_z is applied. 3) Apply second $\pi/2$ pulse with the same phase reference as step 1: $\prod_q R_x(\pi/2)^{(q)}$ (duration $\delta t_{\pi/2}$). The measured expectation values oscillate as $\langle X\rangle_q \sim e^{-(\Gamma_{2,q}\tau)}\cos(2\pi\delta_q\tau)$ and $\langle Y\rangle_q \sim e^{-(\Gamma_{2,q}\tau)}\sin(2\pi\delta_q\tau)$, where $\Gamma_{2,q}$ emerges from the inserted decoherence channels.

Noise: - After each pulse and during the delay, insert depolarizing with $p_{\text{depol},q}$, phase damping $p_{\phi,q} = 1 - e^{-\gamma_{\phi,q}\Delta t_{\text{seg}}}$, amplitude damping $p_{\text{amp},q} = 1 - \exp(-\Delta t_{\text{seg}}(1/T_{1,q} + c_A A_{e,q}))$, coherent detuning $R_z(\epsilon_{z,q})$ with $\epsilon_{z,q} = 2\pi\,\Delta_q\,\Delta t_{\text{seg}}$, and coherent crosstalk rotations induced by the pulses. - Associate time-dependent noise directly to the `delay` instruction of duration τ; apply only dephasing, amplitude damping, and detuning R_z during the delay (no crosstalk if no active drive).

Controller metric during delay (diagnostic):

$$Q_{\text{Ramsey}} := \exp\left(-\frac{1}{n}\sum_q \eta_R|\tilde{\omega}_q - \omega_{e,q}|\right),\ \eta_R = 2.0,\quad \text{CQ} \leftarrow \text{clip}\Big(\text{CQ}\,e^{-\bar{\gamma}_\phi\tau} + (1 - e^{-\bar{\gamma}_\phi\tau})\,Q_{\text{Ramsey}},\ 0, 1\Big).$$

Environment updates after each pulse and during free evolution with the corresponding durations using the complex-field rule.

5.3 Controller Confidence Update (Controller Only)

The controller confidence update models an automated calibration agent's confidence about attractor bitstrings. Maintain a confidence $S_b \in [0,1]$ for bitstring $b \in \{0,1\}^n$ in target set $\mathcal{A}$. Let $\epsilon_0 = 0.01$

and $\epsilon := \epsilon_0\,\iota$. Define

$$\lambda_b := \frac{1}{1+\epsilon/\epsilon_0}\, e^{-k_A \bar{A}_e}, \quad k_A = 0.5, \quad \bar{A}_e = \frac{1}{n}\sum_q A_{e,q},$$

$$S_b \leftarrow \mathrm{clip}\big(\lambda_b\, S_b + (1-\lambda_b), 0, 1\big), \quad \mathcal{A} \leftarrow \mathcal{A} \cup \{b\}.$$

Beliefs $\{S_b\}$ guide controller decisions (e.g., choice of $\boldsymbol{\omega}_s$ or algorithm parameters) but do not directly enter physical noise formulas. In a closed-loop simulation, the controller could use ResonanceFidelity (CQ) to trigger recalibration routines; for example, if CQ drops below a threshold, launch a Ramsey probe to update the controller's estimate of $\boldsymbol{\omega}_e$.

6. Algorithmic Layers

Noise inserted per gate or per block duration.

Bell pairs (even n, $m = n/2$):

$$\left(\prod_{i=0}^{m-1} H^{(i)}\right)\left(\prod_{i=0}^{m-1} \mathrm{CX}_{i,\,i+m}\right).$$

GHZ:

$$H^{(0)} \prod_{i=0}^{n-2} \mathrm{CX}_{i,\,i+1}.$$

Grover (marked $11\ldots1$): initialize with Hadamards; per iteration apply the phase oracle on $11\ldots1$ and diffusion; iterations

$$R = \max\!\Big(1,\ \Big\lfloor \frac{\pi}{4}\sqrt{2^n}\Big\rfloor\Big).$$

QAOA (MaxCut ring), depth $p = 2$ default:

$$\text{init } H^{\otimes n}; \quad \text{for } \ell = 1,2: \left(\prod_{q=0}^{n-2} R_{ZZ}(\gamma_\ell)_{q,q+1}\right)\left(\prod_{q=0}^{n-1} R_x(2\beta_\ell)^{(q)}\right),$$

with heuristics $\gamma_\ell = 2\pi\bar{\omega}_{\text{eff}}$ and $\beta_\ell = \frac{\pi}{4\ell}$, $\bar{\omega}_{\text{eff}} = \frac{1}{n}\sum_q \omega_{\text{eff},q}$. Optionally optimize $(\gamma_\ell, \beta_\ell)$ to maximize $\mathcal{F}_{\text{QAOA}}$ or a scalarized control objective. A primary goal is to track the optimal (γ, β) as a function of the evolving environment state $(\boldsymbol{\omega}_e, \boldsymbol{A}_e)$.

7. Measurement and Parsing

Measurement returns counts; parser strips whitespace and maps to $\{0,1\}^L$. For a data register of length k use

$$\mathrm{tail}_k(x) := \text{last } k \text{ bits of } x.$$

Endianness: rightmost bit is least significant in Qiskit. Optional SPAM: independently flip each bit with probability $p_{\text{spam}} \in [0,1]$ before computing metrics.

8. Metrics

Let parsed counts $C : \{0,1\}^L \to \mathbb{N}$ with $N = \sum_x C(x)$; if $N = 0$, metrics are 0.

Alignment (entropy reduction):

$$p_x = C(x)/N, \quad H(C) = -\sum_{x:C(x)>0} p_x \log_2 p_x, \quad H_{\max} = n, \quad \text{Align} := 1 - \frac{H(C)}{H_{\max}} \ (0/0 := 0).$$

Stability for target subspace $\mathcal{A} \subseteq \{0,1\}^k$:

$$\text{Stab} := \begin{cases} \frac{1}{N}\sum_x C(x)\,\mathbf{1}\{\text{tail}_k(x) \in \mathcal{A}\}, & \mathcal{A} \neq \varnothing, \\ 0, & \mathcal{A} = \varnothing. \end{cases}$$

ResonanceFidelity (diagnostic; replaces CQ): internal CQ $\in [0,1]$.

EnvironmentQuiescence: EnvQ $:= \text{clip}(1 - \bar{A}_e, 0, 1)$ with $\bar{A}_e = \frac{1}{n}\sum_q A_{e,q}$.

Vector performance for analysis:

$$\boldsymbol{M} := \big(\text{Align},\ \text{Stab},\ \text{CQ},\ \text{EnvQ}\big).$$

Scalarized objective (default weighted sum) for optimization:

$$\text{EffCtrl} := \text{clip}\Big(w_1\,\text{Align} + w_2\,\text{Stab} + w_3\,\text{CQ} + w_4\,\text{EnvQ},\ 0, 1\Big),$$

with defaults $(w_1, w_2, w_3, w_4) = (0.4, 0.4, 0.15, 0.15)$. Multiplicative alternative:

$$\text{EffCtrl}_{\Pi} := \Big(\max\{10^{-6}, \text{Align}\} \cdot \max\{10^{-6}, \text{Stab}\} \cdot \max\{10^{-6}, \text{CQ}\} \cdot \max\{10^{-6}, \text{EnvQ}\}\Big)^{1/4}.$$

9. Task-Oriented Fidelities

GHZ, target $\mathcal{T} = \{00\ldots0,\ 11\ldots1\}$:

$$\mathcal{F}_{\text{GHZ}} := \frac{1}{N}\sum_x C(x)\,\mathbf{1}\{\text{tail}_n(x) \in \mathcal{T}\}.$$

Bell pairs (even n, $m = n/2$, pairs $(i, i+m)$). For $x \in \{0,1\}^n$:

$$p_{ab}^{(i)} := \frac{1}{N}\sum_x C(x)\,\mathbf{1}\{x_i = a,\ x_{i+m} = b\},\ a, b \in \{0,1\}.$$

Per-pair fidelity

$$\mathcal{F}_{\text{pair}}^{(i)} := p_{00}^{(i)} + p_{11}^{(i)}, \quad \mathcal{F}_{\text{BellPairs}} := \frac{1}{m}\sum_{i=0}^{m-1} \mathcal{F}_{\text{pair}}^{(i)}.$$

Grover (marked $w = 11\ldots1$):

$$\mathcal{F}_{\text{Grover}} := \frac{1}{N}\sum_x C(x)\,\mathbf{1}\{\text{tail}_n(x) = w\}.$$

QAOA (MaxCut ring; edges $(q, q+1)$, $q = 0, \ldots, n-2$):

$$\langle \widehat{Z_q Z_{q+1}} \rangle = \frac{1}{N} \sum_x C(x)\,(-1)^{x_q \oplus x_{q+1}}, \quad \mathcal{F}_{\text{QAOA}} := \frac{1}{n-1} \sum_{q=0}^{n-2} \left(\frac{1 - \langle \widehat{Z_q Z_{q+1}} \rangle}{2} \right).$$

10. Execution Template

A typical run: (i) MED with chosen $s, T, \delta t$; (ii) Ramsey at $\boldsymbol{\omega}_{\text{eff}}$ with delay τ; (iii) controller confidence updates (e.g., 0^n and 1^n); (iv) an algorithm layer (optionally optimize QAOA and track (γ, β) vs. $(\boldsymbol{\omega}_e, \boldsymbol{A}_e)$); (v) optional interleaved MED or probes; (vi) after each segment, insert noise parameterized by current $(\boldsymbol{\gamma}_\phi, \boldsymbol{T}_1, \boldsymbol{A}_e, G_A, \boldsymbol{A}_{\text{eff}})$; apply coherent R_z errors, coherent crosstalk rotations, and parasitic ZZ; measure per shot; apply optional SPAM; and (vii) compute $\boldsymbol{M} = (\text{Align}, \text{Stab}, \text{CQ}, \text{EnvQ})$, EffCtrl, and task fidelities. In closed loop, use low CQ to trigger recalibration (e.g., a Ramsey probe to update $\boldsymbol{\omega}_e$).

11. Assumptions and Conventions

- Frequency normalization: $\omega \mapsto \omega\,\omega_q$. - Endianness: use tail_k for lower-order bits. - Clipping: $\text{clip}(x, 0, 1) = \min\{1, \max\{0, x\}\}$. - Internal state: $\mathcal{A}$ accumulates attractors; S_b are controller stabilization confidences. - Stochasticity: from sampling, optional SPAM, and simulator randomness. - Coefficients: all numeric constants are calibration knobs with roles noted parenthetically above.

12. Proposed Qiskit Implementation Architecture

Implement a Qiskit `BackendV2`-compatible fake backend class `ControlAwareBackend` encapsulating per-qubit $(\boldsymbol{\omega}_s, \boldsymbol{\phi}_s, \boldsymbol{A}_s)$, effective parameters $(\boldsymbol{\omega}_{\text{eff}}, \boldsymbol{\phi}_{\text{eff}}, \boldsymbol{A}_{\text{eff}})$ via (G_ω, G_ϕ, G_A), environment $(\boldsymbol{\omega}_e, \boldsymbol{E})$, ι, G_A, $T_{1,q}$, and $(\text{CQ}, \mathcal{A}, \{S_b\})$. - Front-end orchestrator: `QuantumOrchestrator` to build circuits with segments: `med(s,T,delta_t)`, `ramsey(tilde_omega_vec,tau,t_pi2)`, `update_confidence(b)`, `run_ghz()`, `run_bell()`, `run_grover()`, `run_qaoa(p, params=None, optimize=False)`. Use `transpile(..., backend=ControlAwareBackend())`. - Backend `run` responsibilities: 1) Parse circuit, detect segment barriers, 2) For each segment/beat, compute $(\{p_{\phi,q}\}, \{p_{\text{amp},q}\}, \{p_{\text{depol},q}\}, \{\epsilon_{z,q}\}, \{\delta\theta_{j\leftarrow k}\}, \{\zeta G_{jk} A_{\text{eff},k}\})$, 3) Update environment via complex-field rule for the segment duration, 4) Inject coherent rotations (R_z, crosstalk $R_{x/y}$, parasitic R_{ZZ}) and Kraus errors; attach noise to `delay` instructions, 5) Update CQ via primitive-specific rule (diagnostic and available to the controller), 6) Execute on a density-matrix or shot-based simulator. - Performance: the most performant approach is a custom transpiler pass that iterates through the circuit, computes state-dependent error parameters per instruction/delay, and inserts concrete `QuantumError`/Kraus operators and coherent rotations directly into the circuit, avoiding repeated `NoiseModel` construction at runtime.

13. Verification Plan

- Environment: relaxation increases with ι and A_{eff}; decays with detuning Δ_q; amplitude and phase co-relax via complex update; frequency tracks drive with same rate. - Noise: $p_{\phi,q}$ increases with $A_{e,q}$ and detuning; amplitude damping rises with $A_{e,q}$ and duration while preserving baseline $T_{1,q}$; $p_{\text{depol},q}$ grows with both local $A_{e,q}$ and global $\bar{A}_e$; coherent R_z captures detuning phase; crosstalk includes spectator rotations and parasitic ZZ. - Ramsey: oscillations in $\langle X\rangle, \langle Y\rangle$ vs. τ at detuning; environment drifts during τ; noise active on `delay`; no terminal R_z is inserted. - MED: CR-like ZX and IX terms proportional to control-qubit drive amplitude; crosstalk yields coherent spectator rotations and parasitic ZZ. - Algorithms: GHZ mass on $\{0^n, 1^n\}$; Bell pairs correlated; Grover peaks at $11\ldots1$; QAOA parameters shift as $(\boldsymbol{\omega}_e, \boldsymbol{A}_e)$ evolve. - Metrics: vector $\boldsymbol{M}$ exposes trade-offs; CQ (ResonanceFidelity) improves near-resonant $\boldsymbol{\omega}_{\text{eff}} \approx \boldsymbol{\omega}_e$; multiplicative EffCtrl_{Π} penalizes weak components.

Dropping the Gauntlet: An Open, Kindly Science-Off

Declaration

(Persona Voice) With love and receipts: for years the discourse around “noise” has often *felt* like an epistemic psyop[a] $\boxed{\checkmark}$. The vibe: “The theory is settled; any mismatch is your hardware.” We reject that framing. We propose a friendly, public, CC0 “science-off” to let data adjudicate $\boxed{\checkmark}$.

(Technical Voice) We issue a reproducible, pre-registered challenge: two small, falsifiable experiments and one algorithmic benchmark. All code and analysis under CC0. Either our control-aware environment model adds measurable, generalizable predictive power—or it does not.

[a] Rhetorical shorthand: we mean social framing that nudges curiosity toward compliance, not a literal operation.

Challenge Protocol (Public, CC0, Preregistered)

P1. Openness. Protocol, code, parameters, and random seeds are posted CC0 prior to runs. Raw results, logs, and analysis notebooks are posted within 48 h of completion.

P2. Parity. Both baselines and our method use the same circuits, shot counts, wall-clock budgets, and (if applicable) hardware windows. No secret calibration passes outside the preregistered set.

P3. Independent Oversight. At least two observers from the open-source quantum community co-sign the preregistration and witness artifact release.

P4. Replicability. Experiments must be rerunnable on a different day or different backend simulator with comparable outcomes (confidence intervals preregistered).

Tasks (Concrete, Falsifiable)

T1 – Ramsey with Explicit Delay. Attach dephasing/amp-damp to `delay`; predict per-qubit decay $\Gamma_{2,q}$ via the environment proxy $A_{e,q}$ from Sec. *(Technical Voice)* **??** (complex-field update). Outcome: correlation $r(\widehat{\Gamma}_{2,q}, \Gamma_{2,q}^{\text{meas}})$.

T2 – MED Pre-Cooling. Interleave short off-resonant “cooling” beats (reduced A_{eff}) before the CR-like MED block. Outcome: reduction in parasitic ZZ estimate and improvement in GHZ fidelity at fixed wall time.

T3 – QAOA Drift Tracking. Track argmax of (γ, β) for MaxCut ring as $(\boldsymbol{\omega}_e, \boldsymbol{A}_e)$ evolve. Outcome: predictive accuracy of our proxy on the direction/magnitude of the parameter drift and resulting objective change.

Scoring (Pre-Registered, Scalarized)

Let

$$\Delta\mathcal{F}_{\text{GHZ}} := \mathcal{F}^{\text{ours}}_{\text{GHZ}} - \mathcal{F}^{\text{base}}_{\text{GHZ}}, \quad \Delta ZZ := ZZ^{\text{base}} - ZZ^{\text{ours}},$$

$$r_{\text{Ramsey}} := r\Big(\widehat{\Gamma}_{2,q}, \Gamma^{\text{meas}}_{2,q}\Big), \quad \Delta\text{KL} := \text{KL}\big(p_{\text{meas}} \,\|\, p_{\text{base}}\big) - \text{KL}\big(p_{\text{meas}} \,\|\, p_{\text{ours}}\big).$$

Overall score (clipped to $[0,1]$):

$$\text{Score} = \text{clip}\Big(0.35\,\Delta\mathcal{F}_{\text{GHZ}} + 0.25\,\Delta ZZ + 0.25\,r_{\text{Ramsey}} + 0.15\,\sigma(\Delta\text{KL})\Big),$$

with $\sigma(x) = \frac{1}{1+e^{-x}}$. Confidence intervals and tie-breakers (e.g. bootstrap on shots) are preregistered.

Etiquette and Ethics

(Persona Voice) We fight memes with measurements, not people with posts. *(Technical Voice)* No ad hominem, no dogpiles. All artifacts are CC0; all negative results will be posted. We include a one-page *Declaration of Non-Harassment* in the repository and invite all parties to co-sign.

How to Accept

Open a public issue titled `Science-Off Acceptance` in the repository, co-sign the preregistration template, and nominate observers. We schedule a two-week window, then publish everything (pass or fail).

If we win: you get a better model. If we lose: you get a clearer truth. Either way, science wins.

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