LASER: Lagrangian And Symmetry for Engagement Resonances: A gauge-invariant field theory of marketing as a complex system

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Abstract

We develop a gauge-invariant, QFT-inspired framework for marketing conceived as a complex socio- technical system. Consumers, brands, and media infrastructures are modeled as interacting fields over a configuration space, while attention and engagement are represented as quanta in a bosonic Fock space—a natural language for cascades in which the *number* of acts is itself dynamical. Within this structure we formalize (i) contextuality of marketing observables under incompatible measurement contexts (via Kochen–Specker-type projection structure), (ii) interference of combined interventions through amplitude superposition with constructive/destructive cross terms, (iii) coherent gain-threshold *laser events* defined as macroscopic jumps of regional number operators under inversion and sufficiently long coherence length, and (iv) scale-dependent effective couplings induced by coarse-graining, suggesting renormalization-style analysis for segment-level response. To keep one foot on the pavement, we include an evolutive campaign design loop for a new men's perfume in New York City: the target "inversion" is a 10× sales uplift, while *budget* and *cadence* act as explicit controls that adapt to measurable proxies for inversion, coherence, and stimulated-response gain. Finally, two conversation-dynamics reductions— a double-delta tunneling model and a two-mode bosonic GKSL (Lindblad) system—illustrate how low- dimensional quantum and open-system models arise as controlled truncations of the field picture. The aim is not immediate calibration, but a principled phenomenological vocabulary that surfaces interference, thresholds, and scale effects for modeling and designing interventions in complex systems.

Received Date
Accepted Date
Published Date

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1 Introduction

Much of marketing theory, in its calmer moments, treats consumers as nearly independent decision units: preferences perturbed by noise, bounded rationality, or the occasional advertising shock [8]. Contemporary socio-technical settings are less polite: bursts, cascades, abrupt shifts in framing, and cross-platform amplification are emergent properties of interacting populations embedded in media infrastructures. A quantum field-theoretic (QFT) perspective offers a compact way to write down that interaction by representing attitudes, meanings, and social energy as coupled fields distributed over a configuration space, and by treating attention, engagement, and informational acts as discrete quanta whose collective occupation can change abruptly under driving [1, 2, 12, 13, 17].

This article gives a precise, theory-forward formulation of a “quantum field theory of marketing”. The intent is not to mystify marketing with physics metaphors, but to import the bookkeeping that field theory uses whenever (i) interactions are local yet consequences propagate, (ii) heterogeneity matters, and (iii) the number of events is itself dynamical. We introduce explicit definitions, assumptions, and structural results that organize context effects, interference, coherence, and scale within a single field-theoretic vocabulary, drawing conceptual input from quantum models of cognition/decision and quantum social science [3, 7, 14]. Related gauge-inspired approaches to market and social dynamics appear, e.g., in [9]. The presentation is intentionally theory-forward: we focus on the formal architecture and its qualitative consequences rather than immediate empirical calibration, and we include concrete reductions to conversation dynamics (Section 7) to show how familiar low-dimensional quantum and open-system models arise as controlled truncations of the broader field picture.

1.1 Field-theoretic vs. finite-dimensional quantum models

Most quantum-like models of cognition and decision operate in a finite-dimensional Hilbert space associated with a single decision maker or a small group [3, 7]. In such models, a state $\psi \in \mathcal{H}$ encodes the relevant information, and changes in context are represented by different projectors or unitaries on $\mathcal{H}$. This formalism captures order effects, context dependence, and interference in controlled tasks, but it is less explicit about how local interactions propagate through heterogeneous populations, how correlations extend across network distance, and how effective behavior changes under aggregation.

A field-theoretic description makes these complex-systems features explicit by introducing a configuration space $\mathcal{X}$ and fields defined on it:

- A cognitive field $\Psi(x,t)$, brand fields $B_i(x,t)$, and media/gauge fields $A_\mu(x,t)$ encode how attitudes, meanings, and conversational flows vary across socio-demographic, psychographic, platform, and network coordinates $x \in \mathcal{X}$, allowing local interventions to generate nonlocal consequences through propagation and coupling.
- A (bosonic) attention/engagement Fock space represents states with a variable number of engagement quanta distributed over modes, natural for cascades and bursts in which the total count of acts is itself dynamical.
- A Lagrangian density $\mathcal{L}$ (and associated Euler-Lagrange, path-integral, or open-system reductions) encodes locality, coupling structure, and symmetries, constraining admissible dynamics and observables.

In this sense, the present framework does not replace finite-dimensional quantum cognition; it embeds it. A laboratory-scale quantum-like model corresponds to fixing x (or restricting to a small region of $\mathcal{X}$) and projecting onto a finite-dimensional subspace capturing a few salient modes. The added field structure targets settings where heterogeneity, networked propagation, distributed media, and explicit multi-scale aggregation are central.

2 Preliminaries

We use standard notation from functional analysis and quantum theory [12, 13]. A complex Hilbert space is denoted by $\mathcal{H}$ with inner product $\langle \cdot, \cdot \rangle$ linear in its second argument.

2.1 Marketing configuration space

Definition 2.1 (Marketing configuration space)**.** A *marketing configuration space* is a measurable space $(\mathcal{X}, \Sigma)$ whose points $x \in \mathcal{X}$ represent micro-contexts of marketing relevance (e.g., socio-demographic coordinates, psychographic attributes, platform states, local network structure). The σ-algebra Σ collects configuration events that are observationally or analytically accessible.

Assumption 2.2 (Differentiable structure when derivatives are used)**.** Whenever derivatives ∂_j, ∇, or Δ appear, we assume $\mathcal{X}$ is a smooth d-dimensional manifold (or an open subset of $\mathbb{R}^d$) equipped with local coordinates and a volume measure $\mathrm{d}x$ compatible with the intended coarse-graining.

Remark 2.3. The choice of $\mathcal{X}$ is theory-laden: different levels of aggregation correspond to different configuration spaces. Renormalization-type constructions (Section 6) relate models built on different resolutions of $\mathcal{X}$.

2.2 State spaces and fields

Definition 2.4 (Consumer cognitive state space)**.** Let $\mathcal{H}_c$ be a separable complex Hilbert space. A unit vector $\psi \in \mathcal{H}_c$ represents a *pure cognitive state* of a consumer (or homogeneous micro-segment) and a density operator ϱ on $\mathcal{H}_c$ represents a possibly mixed state. Observables are represented by bounded self-adjoint operators on $\mathcal{H}_c$.

Definition 2.5 (Consumer cognitive field)**.** A *consumer cognitive field* is a measurable map

$$\Psi : \mathcal{X} \times \mathbb{R} \to \mathcal{H}_c$$

such that for each fixed t, the map $x \mapsto \langle \Psi(x,t), A\Psi(x,t) \rangle$ is measurable for every bounded operator A on $\mathcal{H}_c$.

Definition 2.6 (Brand fields)**.** For each brand, product, or offering i in a finite or countable index set I, let $\mathcal{H}_{B_i}$ be a Hilbert space representing its latent meaning/attribute space. A *brand field* is a measurable map

$$B_i : \mathcal{X} \times \mathbb{R} \to \mathcal{H}_{B_i}.$$

2.3 Social-information gauge structure

Definition 2.7 (Social-information gauge field)**.** Fix $d \geq 1$ and write spacetime as $(x,t) \in \mathcal{X} \times \mathbb{R}$. Let $G = U(1)$ and let $\mathcal{A}$ denote the affine space of $U(1)$ gauge field configurations

$$A = (A_\mu)_{\mu=0,\dots,d}, \qquad A_\mu : \mathcal{X} \times \mathbb{R} \to \mathbb{R},$$

where A_0 is a scalar potential and A_j $(j = 1, \dots, d)$ are spatial components.

Remark 2.8. $U(1)$ is a minimal choice: it corresponds to a single phase degree of freedom attached to narrative representations. More elaborate non-abelian groups can represent multidimensional framing spaces; $U(1)$ already captures local reparameterizations of a dominant narrative "phase" across $\mathcal{X}$ and t.

Definition 2.9 (Gauge charges and transformations)**.** Let $q_c \in \mathbb{R}$ be the $U(1)$ charge of the consumer field and $q_i \in \mathbb{R}$ the charge of brand i. A *gauge transformation* is specified by a smooth function $\chi : \mathcal{X} \times \mathbb{R} \to \mathbb{R}$ acting on fields by

$$\begin{aligned}
\Psi(x,t) &\mapsto \Psi'(x,t) = e^{iq_c\chi(x,t)}\Psi(x,t),\\
B_i(x,t) &\mapsto B_i'(x,t) = e^{iq_i\chi(x,t)}B_i(x,t),\\
A_\mu(x,t) &\mapsto A_\mu'(x,t) = A_\mu(x,t) - \partial_\mu\chi(x,t),
\end{aligned}$$

where $\partial_0 = \partial_t$ and ∂_j is the derivative w.r.t. the j-th spatial coordinate.

Definition 2.10 (Covariant derivatives and field strength)**.** Define the covariant derivative of the consumer field by

$$D_\mu \Psi := (\partial_\mu + i q_c A_\mu)\Psi,$$

and analogously for each brand field B_i with charge q_i. The *field strength* (curvature) is

$$F_{\mu\nu} := \partial_\mu A_\nu - \partial_\nu A_\mu, \qquad \mu, \nu = 0, \ldots, d.$$

Under gauge transformations,

$$D_\mu \Psi \mapsto e^{i q_c \chi} D_\mu \Psi, \qquad F_{\mu\nu} \mapsto F_{\mu\nu}.$$

A minimal gauge-invariant contribution to the Lagrangian density can be written as

$$\mathcal{L}^{\text{gauge}}_{\text{consumer}} = \frac{i}{2}\Big(\Psi^\dagger D_0 \Psi - (D_0\Psi)^\dagger \Psi\Big) - \frac{1}{2m}\sum_{j=1}^{d} (D_j\Psi)^\dagger (D_j\Psi) - U_c(x)\,\Psi^\dagger \Psi, \tag{1}$$

$$\mathcal{L}^{\text{gauge}}_{\text{media}} = -\frac{1}{4}\sum_{\mu,\nu=0}^{d} F_{\mu\nu}F_{\mu\nu}. \tag{2}$$

Remark 2.11 (Marketing interpretation of gauge symmetry)*.* Gauge-equivalence classes of $(\Psi, \{B_i\}, A)$ correspond to descriptions that differ only by local reparameterizations of a background narrative frame. Observable outcomes depend only on gauge-invariant combinations such as $(D_\mu\Psi)^\dagger(D_\mu\Psi)$, $B_i^\dagger B_i$, and $F_{\mu\nu}F_{\mu\nu}$, not on the particular "phase" $\chi(x,t)$. In this reading, A_μ encodes how local framing shifts across $\mathcal{X}$ and t must be compensated to preserve invariance of observable behavior.

2.4 Fock space of attention and engagement

Definition 2.12 (Attention/engagement quanta and bosonic Fock space)**.** Fix a Hilbert space $\mathcal{H}_{ae}$ whose basis vectors correspond to micro-states of attention and engagement (e.g., focused attention on a brand, click, share, purchase). The associated *bosonic* Fock space is

$$\mathcal{F}_{ae} := \mathcal{F}_s(\mathcal{H}_{ae}),$$

equipped with creation/annihilation operators $a^\dagger(f)$ and $a(f)$ for $f \in \mathcal{H}_{ae}$ and number operators $N = \mathrm{d}\Gamma(I)$.

Remark 2.13. The Fock picture makes it natural to model campaign effects as creation/annihilation of engagement quanta: a post is made, a share is not, a comment arrives late, a thread dies out. In other words, the "number of particles" in the model is not a fixed population of agents but a fluctuating count of acts distributed over modes. This is a mundane point in quantum field theory, and it is equally mundane in media systems.

Open-system evolution of reduced conversation modes is modeled by a Lindblad-type quantum Markov semigroup (GKSL form) [6, 11]. We also rely on standard results from quantum foundations (Kochen-Specker and Gleason) when discussing contextuality [5, 10].

3 Marketing systems as interacting quantum fields

3.1 Structural definition

Definition 3.1 (Quantum field theoretic marketing system)**.** A *QFT marketing system* is a tuple

$$M = (\mathcal{X}, \Sigma, \mathcal{H}_c, \{\mathcal{H}_{B_i}\}_{i\in I}, \mathcal{A}, \mathcal{H}_{ae}, \mathcal{F}_{ae}, \mathcal{L})$$

where

- $(\mathcal{X}, \Sigma)$ is a marketing configuration space (Definition 2.1);
- $\mathcal{H}_c$ is the consumer cognitive state space and $\Psi : \mathcal{X} \times \mathbb{R} \to \mathcal{H}_c$ is a cognitive field (Definition 2.5);
- $\mathcal{H}_{B_i}$ and $B_i : \mathcal{X} \times \mathbb{R} \to \mathcal{H}_{B_i}$ are brand fields;
- $\mathcal{A}$ is the space of social-information gauge fields A (Definition 2.7);
- $\mathcal{H}_{ae}$ is the one-quantum engagement space and $\mathcal{F}_{ae}$ its bosonic Fock space (Definition 2.12);
- $\mathcal{L}$ is a Lagrangian density decomposed as

$$\mathcal{L} = \mathcal{L}_{\text{consumer}} + \mathcal{L}_{\text{brand}} + \mathcal{L}_{\text{media}} + \mathcal{L}_{\text{int}}.$$

Assumption 3.2 (Regularity)**.** We assume $\mathcal{L}$ is sufficiently smooth and the relevant variational calculus applies, so that Euler-Lagrange equations define well-posed field dynamics for $(\Psi, \{B_i\}, A)$ on the intended function spaces.

3.2 Interaction Lagrangian

Definition 3.3 (Interaction terms)**.** An *interaction Lagrangian* $\mathcal{L}_{\text{int}}$ is a functional of $(\Psi, \{B_i\}, A)$ of the form

$$\mathcal{L}_{\text{int}} = \sum_{i \in I} g_i \, \mathcal{J}_i(\Psi, A) \, B_i + \lambda \, \mathcal{K}(\Psi, A),$$

where g_i and λ are couplings and $\mathcal{J}_i, \mathcal{K}$ are scalar functionals encoding, respectively: (i) consumer-brand susceptibility and (ii) media-induced pumping/framing and noise.

Remark 3.4. In concrete models, $\mathcal{J}_i$ can depend on local overlaps $\langle \Psi(x,t), \hat{O}_i B_i(x,t) \rangle$ for suitable operators $\hat{O}_i$, while $\mathcal{K}$ can encode exposure or social influence driven by A_μ.

3.3 A minimal scalar single-brand model (illustrative reduction)

To make the decomposition $\mathcal{L} = \mathcal{L}_{\text{consumer}} + \mathcal{L}_{\text{brand}} + \mathcal{L}_{\text{media}} + \mathcal{L}_{\text{int}}$ concrete, we describe a minimal reduced scalar model with one brand and one media channel.

Ingredients. Assume $\mathcal{X} \subset \mathbb{R}^d$ (Assumption 2.2). Let

- $\psi : \mathcal{X} \times \mathbb{R} \to \mathbb{C}$ be a complex scalar *cognitive amplitude* (projection of Ψ),
- $b : \mathcal{X} \times \mathbb{R} \to \mathbb{C}$ be a complex scalar *brand excitation* (reduction of B_i),
- $A : \mathcal{X} \times \mathbb{R} \to \mathbb{R}$ be a real scalar *media intensity*.

Let $m > 0$ be a consumer inertia parameter, $v_B, v_A > 0$ propagation speeds, $m_B \geq 0$ a brand stiffness parameter, and $U_c : \mathcal{X} \to \mathbb{R}$ a static potential encoding baseline friction.

Lagrangians.

$$\mathcal{L}_{\text{consumer}} = \frac{i}{2}\big(\psi^*\partial_t\psi - \psi\,\partial_t\psi^*\big) - \frac{1}{2m}|\nabla\psi|^2 - U_c(x)|\psi|^2, \tag{3}$$

$$\mathcal{L}_{\text{brand}} = \frac{1}{2v_B^2}|\partial_t b|^2 - \frac{1}{2}|\nabla b|^2 - \frac{m_B^2}{2}|b|^2, \tag{4}$$

$$\mathcal{L}_{\text{media}} = \frac{1}{2v_A^2}(\partial_t A)^2 - \frac{1}{2}|\nabla A|^2, \tag{5}$$

180 and the simplest local couplings

$$\mathcal{L}_{\text{int}} = g_A A(x,t)\,|\psi(x,t)|^2 + g_B\,\Re\big(\psi^*(x,t)b(x,t)\big), \tag{6}$$

181 where $g_A, g_B \in \mathbb{R}$.

182 **Action.** Over $D \times [t_0, t_1]$,

$$S[\psi, b, A] = \int_{t_0}^{t_1}\int_D \big(\mathcal{L}_{\text{consumer}} + \mathcal{L}_{\text{brand}} + \mathcal{L}_{\text{media}} + \mathcal{L}_{\text{int}}\big)\,\mathrm{d}x\,\mathrm{d}t.$$

183 **Euler-Lagrange equations.** Treating ψ and ψ^* as independent fields, we obtain

$$i\,\partial_t\psi = -\frac{1}{2m}\Delta\psi + U_c(x)\psi + g_A A\psi + \frac{g_B}{2}b, \tag{7}$$

$$\frac{1}{v_B^2}\,\partial_t^2 b - \Delta b + m_B^2 b = \frac{g_B}{2}\psi, \tag{8}$$

$$\frac{1}{v_A^2}\,\partial_t^2 A - \Delta A = g_A|\psi|^2. \tag{9}$$

184 *Remark* 3.5 (Reduced-QFT interpretation). Equations (7)-(9) provide a concrete starting point
185 for simulation, perturbation analysis, or stochastic extensions, while retaining the field-theoretic
186 structure.

187 # 4 Contextuality and interference in campaigns

188 ## 4.1 Observables and measurement contexts

189 **Definition 4.1** (Marketing observable)**.** A *marketing observable* is a self-adjoint operator M on
190 $\mathcal{H}_c \otimes \mathcal{F}_{ae}$ representing a measurable marketing outcome (purchase incidence, brand choice,
191 engagement level) in a specified experimental/campaign context.

192 **Definition 4.2** (Context)**.** A *context* consists of: (i) a set of commuting observables $\{M_1, \ldots, M_k\}$
193 and (ii) external field values $(A, \{B_i\})$ over a region of $\mathcal{X}$ and time window. Two contexts are
194 *compatible* if all associated observables commute, and *incompatible* otherwise.

195 **Lemma 4.3** (Quantum-like contextuality)**.** *Assume* $\dim(\mathcal{H}_c \otimes \mathcal{F}_{ae}) \geq 3$. *Let C and C' be two*
196 *incompatible contexts, and let $\mathcal{A}$ be the von Neumann algebra generated by the projectors available*
197 *across $C \cup C'$. Suppose there exists a three-dimensional subspace $\subset \mathcal{H}_c \otimes \mathcal{F}_{ae}$ invariant under $\mathcal{A}$*
198 *such that the restriction of $\mathcal{A}$ to contains a Kochen-Specker (KS) set of projections. Then there*
199 *exists a state ϱ and a finite family of events built from C and C' whose probability assignments*
200 *cannot be embedded into a single Kolmogorov probability space.*

Proof. On the invariant subspace $\simeq \mathbb{C}^3$, the assumed KS set forbids any $\{0,1\}$-valued homomorphism on the projection lattice preserving all functional relations [10]. Choosing a state ϱ that assigns nontrivial probabilities to these projections, the associated yes/no events cannot be represented as indicator functions on a single classical sample space; otherwise such a homomorphism would exist. Hence the induced probabilities are non-Kolmogorovian, i.e. contextual. □

4.2 Interference of campaigns

Definition 4.4 (Campaign as field perturbation)**.** A *campaign* is a temporally localized perturbation of the interaction Lagrangian,

$$\delta\mathcal{L}_{\mathrm{int}}(t) = \sum_{i\in I} u_i(t)\,\mathcal{J}_i(\Psi,A)\,B_i,$$

where $u_i(t)$ encodes temporal profile and allocation (e.g. budget, creative intensity) for brand i.

Definition 4.5 (Consumer journey as path)**.** For region $D \subseteq \mathcal{X}$ and time interval $[t_0,t_1]$, a *consumer journey* is a path γ in the space of field configurations restricted to $D\times[t_0,t_1]$. The associated action is

$$S[\gamma] = \int_{t_0}^{t_1}\int_D \mathcal{L}(\gamma(x,t))\,\mathrm{d}x\,\mathrm{d}t.$$

Proposition 4.6 (Interference of campaign paths)**.** *Consider two distinct campaign strategies U and V, modeled by perturbations $\delta\mathcal{L}^U_{int}$ and $\delta\mathcal{L}^V_{int}$. Assume the resulting propagators for an outcome event E can be represented by complex amplitudes $\alpha_U(E)$ and $\alpha_V(E)$. Under superposition of the campaigns, the total probability of E is*

$$P_{U+V}(E) = |\alpha_U(E)+\alpha_V(E)|^2 = P_U(E)+P_V(E)+2\,\Re\big(\alpha_U(E)\overline{\alpha_V(E)}\big),$$

where $P_U(E)=|\alpha_U(E)|^2$ and $P_V(E)=|\alpha_V(E)|^2$. The cross term is an interference term that can be strictly positive (constructive) or negative (destructive).

Proof. By assumption, the mapping from control perturbation to event amplitude is linear at the amplitude level. Therefore $\alpha_{U+V}(E)=\alpha_U(E)+\alpha_V(E)$, and the Born rule yields the stated expansion. □

Remark 4.7. Combined campaigns are not generally additive: sequencing and framing can shift phases, producing amplification or cancellation in aggregate outcomes.

5 Social energy and coherent gain thresholds

5.1 Social energy density and inversion

Definition 5.1 (Social energy density)**.** Let $\mathcal{E}(x,t)$ be a positive functional of (Ψ,A) at configuration x and time t, interpreted as *social energy density* (e.g. arousal, dissatisfaction, enthusiasm, urgency). We say that the system exhibits a *population inversion* on a region $D\subseteq\mathcal{X}$ at time t if

$$\int_D \mathcal{E}(x,t)\,\mathrm{d}x \;>\; \int_D \mathcal{E}_{\mathrm{ground}}(x)\,\mathrm{d}x,$$

where $\mathcal{E}_{\mathrm{ground}}$ is a baseline (ground) energy density.

Definition 5.2 (Coherence length)**.** For a field configuration (Ψ,A), the *coherence length* ℓ_c on a region D is the maximal length scale over which the relevant two-point correlation functions (e.g. phase correlations of a dominant engagement mode) remain above a specified threshold.

5.2 Laser events (coherent gain thresholds)

To formalize abrupt engagement bursts, define a *regional* number operator. Let P_D be a projection on $\mathcal{H}_{ae}$ selecting engagement modes supported in (or attributable to) region D. Define

$$N_D := \mathrm{d}\Gamma(P_D),$$

the second-quantized number operator counting engagement quanta in D.

Definition 5.3 (Laser event)**.** A *coherent amplification event* associated with a brand or cause occurs on $D \times [t_0, t_1]$ if the following hold:

1. (Population inversion) There exists $t^* \in [t_0, t_1]$ such that D exhibits a population inversion in the sense of Definition 5.1.
2. (High coherence) At t^*, the coherence length $\ell_c(D, t^*)$ exceeds a critical value $\ell_c^{\mathrm{crit}}(D)$ determined by the effective geometry/diameter of D.
3. (Gain threshold) A campaign perturbation $\delta\mathcal{L}_{\mathrm{int}}$ active near t^* couples to the relevant engagement modes such that, for the system state $\varrho(t)$ on $\mathcal{H}_c \otimes \mathcal{F}_{ae}$,

$$\langle N_D \rangle_{t_1} - \langle N_D \rangle_{t_0} \geq N_{\mathrm{crit}},$$

where $\langle N_D \rangle_t := \mathrm{Tr}\big(\varrho(t) N_D\big)$ and $N_{\mathrm{crit}} > 0$ is a macroscopic threshold.

Remark 5.4. Definition 5.3 isolates three distinct design levers (and keeps them separate, which is often the hard part): (i) build inversion (latent readiness), (ii) increase coherence (shared framing and correlated attention), and (iii) time a perturbation that couples strongly to the coherent mode.

6 Multi-scale structure and renormalization

A key advantage of an explicit configuration space is the ability to define coarse-graining and ask how effective couplings change with aggregation level.

6.1 Coarse-graining and effective actions

Fix a scale parameter $\ell > 0$ (segment resolution). Let $\mathcal{C}_\ell$ be a coarse-graining operator mapping fine-grained fields to effective fields on a coarser configuration space $\mathcal{X}_\ell$:

$$(\Psi, B, A) \mapsto (\Psi_\ell, B_\ell, A_\ell) = \mathcal{C}_\ell(\Psi, B, A).$$

Define an effective action S_ℓ by integrating out fluctuations below scale ℓ:

$$e^{-S_\ell[\Psi_\ell, B_\ell, A_\ell]} := \int \exp\{-S[\Psi, B, A]\}\, \delta\big(\mathcal{C}_\ell(\Psi, B, A) - (\Psi_\ell, B_\ell, A_\ell)\big)\, \mathcal{D}\Psi\, \mathcal{D}B\, \mathcal{D}A.$$

This mirrors Wilsonian renormalization, with ℓ representing aggregation over marketing configurations rather than momentum [16].

6.2 Beta functions (effective-coupling flow)

Let $\boldsymbol{g}(\ell) = (g_1(\ell), \ldots, g_n(\ell))$ denote the vector of effective couplings appearing in S_ℓ. A renormalization-group style flow is specified by beta functions

$$\beta_k(\boldsymbol{g}) := \frac{\mathrm{d}g_k}{\mathrm{d}\ln \ell},$$

analogous to Callan-Symanzik/Wilson flow equations [4, 15, 16].

Example 6.1 (Scale-dependent price sensitivity)**.** Consider a fine-scale logit-like response with utility $U = -\alpha p + \cdots$ where α is an individual price sensitivity. Under coarse-graining (mixing heterogeneous α across a segment), the effective segment-level response can become less elastic than the mean due to selection and saturation, motivating a scale-dependent $\alpha(\ell)$.

7 Conversation dynamics reductions

This section illustrates how familiar low-dimensional quantum models embed into the field picture by restricting attention to a small set of conversational/attention modes and treating the remainder as an environment.

7.1 Single-particle double-delta tunneling (overt/covert theme switching)

Consider a one-dimensional reduction where a single conversational theme coordinate $x \in \mathbb{R}$ parameterizes a continuum between two interpretive basins. Let the effective Hamiltonian be

$$H = -\frac{\hbar^2}{2m}\frac{\mathrm{d}^2}{\mathrm{d}x^2} + V(x), \qquad V(x) = \lambda\big(\delta(x-a) + \delta(x+a)\big),$$

a solvable model of scattering and tunneling [18]. In this interpretation, the two δ-barriers represent friction points (attention costs, platform constraints, social risk), and tunneling corresponds to switching between overt and covert interpretations.

7.2 Two-mode bosonic model with GKSL noise (oscillation and thermalization)

Let a_1, a_2 be bosonic annihilation operators for two engagement modes (e.g. two competing narrative framings, or two platforms). Consider the Hamiltonian

$$H = \omega_1 a_1^\dagger a_1 + \omega_2 a_2^\dagger a_2 + J(a_1^\dagger a_2 + a_2^\dagger a_1),$$

and an open-system GKSL dynamics for the mode state $\varrho(t)$:

$$\frac{\mathrm{d}\varrho}{\mathrm{d}t} = -i[H, \varrho] + \sum_k \gamma_k \left(L_k \varrho L_k^\dagger - \frac{1}{2}\{L_k^\dagger L_k, \varrho\} \right),$$

where $\{\cdot,\cdot\}$ is the anticommutator and L_k are Lindblad operators [6, 11]. Here J controls coherent oscillations (attention exchange between modes), while damping/dephasing models noise and attention decay.

8 Evolutive campaign design for coherent gain threshold laser events

A physicist will naturally ask where the photons are. Here they are replaced by people, which is less tidy but more interesting. The purpose of this section is to take the formal objects already defined—fields on a configuration space, a regional number operator, and a gain threshold—and turn them into an evolutive (adaptive) campaign recipe that can be run without pretending that Manhattan is a vacuum chamber.

We consider a new men's perfume launch in New York City. The design objective is an "inversion" corresponding to a sustained 10× uplift in sales relative to baseline, while the practical control knobs are (i) total spend and allocation (budget) and (ii) the timing structure of exposures (cadence). The QFT vocabulary contributes two things: it forces us to separate *readiness* (inversion) from *alignment* (coherence), and it gives a crisp definition of what we are trying to trigger: a *laser event* in the sense of Definition 5.3, i.e. a macroscopic jump of a regional engagement count under coherent gain rather than diffuse noise.

8.1 System, region, and target inversion

Region and modes. Let $D \subset \mathcal{X}$ denote the New York City campaign region (geographical and platform/community slices), and let P_D be the engagement-mode projection used in Definition 5.3. The regional number operator

$$N_D = \mathrm{d}\Gamma(P_D)$$

counts engagement quanta attributable to D (e.g., qualified visits, shares, saves, add-to-cart, purchases), with the precise attribution rule treated as an implementation choice.

Inversion target as a sales constraint. Let $S(t)$ denote an observed sales process (e.g., weekly units sold in NYC across channels). Let $S_{\text{base}}(t)$ denote a counterfactual baseline (historical trend or holdout estimate). In this case study the required *inversion* is a 10× increase in sales over baseline over a campaign horizon $[t_0, t_1]$:

$$\exists\, t^* \in [t_0, t_1] \ \text{ s.t. } \ \frac{S(t^*)}{S_{\text{base}}(t^*)} \geq 10.$$

Phenomenologically, this sales inversion is treated as a macro-level proxy for the population inversion condition of Definition 5.1: the campaign must pump latent readiness and perceived relevance in D beyond its ground level.

8.2 Controls: budget and cadence as field perturbations

We operationalise the campaign as a control perturbation of the interaction Lagrangian (Definition 3.5), specialising to a single focal brand:

$$\delta\mathcal{L}_{\text{int}}(t) = u(t)\,\mathcal{J}(\Psi, A)\,B,$$

where $u(t)$ is a scalar control.

Budget control. Let $b(t) \geq 0$ denote instantaneous spend rate (or a discretised spend per interval). We model budget as controlling the *amplitude* of $u(t)$:

$$u(t) = \alpha\, b(t)\, c(t),$$

with $\alpha > 0$ an effectiveness scale and $c(t) \in [0, 1]$ a normalised cadence/envelope.

Cadence control. Cadence encodes *when* interventions occur and how sharply they are delivered (pulses versus smooth waves). A convenient parametrisation is a pulse train with adaptive pulse times $\{t_k\}$:

$$c(t) = \sum_{k=1}^{K} w_k \, \kappa_\tau(t - t_k),$$

where κ_τ is a smooth kernel of width τ (release window), and w_k are per-pulse weights (creative intensity, channel mix emphasis). In the field picture, cadence is the mechanism that attempts to *phase-align* engagement modes to increase coherence length ℓ_c before triggering a threshold jump.

8.3 Coherence engineering: narrative gauge alignment

Within the gauge vocabulary, coherence is increased when the effective phase structure across D is aligned. Operationally, for a perfume launch in NYC, coherence building corresponds to: (i) stabilising a dominant frame (e.g., "night-out confidence", "clean modern power", "NYC signature"), (ii) maintaining consistent symbolic anchors (olfactory notes, visual codes, taglines), and (iii) ensuring cross-channel consistency so that local reparameterisations (gauge transformations) do not destroy interference structure.

In the model, coherence is tracked through the phenomenological coherence length $\ell_c(D,t)$ (Definition 5.2). A practical proxy is any cross-platform synchrony metric (e.g., topic/embedding alignment across creators and channels) that correlates with sustained constructive interference in Proposition 4.6.

8.4 Laser-event condition for a *series* of threshold crossings

Definition 5.3 specifies a single laser event on $D \times [t_0, t_1]$. For an evolutive campaign we seek *multiple* threshold crossings at times $t_1 < t_2 < \cdots < t_K$ while maintaining the inversion/coherence prerequisites. We therefore define target event times $\{t_k\}$ such that

$$\langle N_D \rangle_{t_k^+} - \langle N_D \rangle_{t_k^-} \geq N_{\text{crit}}, \qquad k = 1, \ldots, K,$$

with $t_k^{\pm}$ denoting times immediately after/before the k-th pulse window. The campaign is successful if these events occur while the macro inversion proxy is sustained:

$$\max_{t \in [t_0, t_1]} \frac{S(t)}{S_{\text{base}}(t)} \geq 10,$$

and coherence remains above criticality near each t_k:

$$\ell_c(D, t_k) \geq \ell_c^{\text{crit}}(D) \qquad \text{for all } k.$$

8.5 Evolutive control loop (measurement → update → pulse)

An evolutive campaign is naturally expressed as a receding-horizon feedback policy in which measurements update both budget allocation and cadence. At discrete decision times n (e.g., daily/weekly), observe a sufficient statistic

$$y_n = \left(\widehat{\langle N_D \rangle}, \widehat{\ell}_c, \widehat{\mathcal{E}}, \widehat{S}/\widehat{S}_{\text{base}} \right)_n,$$

where hats indicate operational estimates/proxies. Then update control parameters $(b(\cdot), \{t_k\}, \{w_k\})$ to maximise the probability of future threshold jumps subject to constraints.

A minimal abstract optimisation is:

$$\max_{u(\cdot)} \sum_{k=n}^{n+H} \mathbb{P}\Big(\langle N_D\rangle_{t_k^+} - \langle N_D\rangle_{t_k^-} \geq N_{\mathrm{crit}}\Big) \quad \text{s.t.} \quad \int_{t_n}^{t_{n+H}} b(t)\,\mathrm{d}t \leq B_{\mathrm{rem}},$$

where H is a planning horizon and B_{rem} is remaining budget. In practice, one replaces the probability with a surrogate objective based on measured slopes and coherence proxies, but the control-theoretic structure remains.

8.6 Concrete implementation for a new men's perfume in New York City

We translate the three levers in Definition 5.3 into an implementable sequence.

Phase I (pump/invert): build latent readiness. Goal: increase $\mathcal{E}(x,t)$ in NYC segments that plausibly convert (nightlife, fashion, finance, creative industries) using sampling, retail seeding, and short-form creative that signals identity benefits. In the model this is increasing $\int_D \mathcal{E}(x,t)\mathrm{d}x$ above ground. Operationally, the budget control $b(t)$ is biased toward reach and trial proxies (sample redemption, store visits, search lift).

Phase II (cohere): align the dominant frame across channels. Goal: increase $\ell_c(D,t)$ by converging on a stable narrative phase. Use a small set of consistent anchors (scent story, visual motif, NYC-located micro-scenes) and enforce cross-channel invariances (same semantic core; local stylistic variation allowed). This is where gauge invariance is a design constraint: allow local reparameterisation without changing the gauge-invariant observables that support constructive interference.

Phase III (stimulate): cadence-controlled pulses to trigger threshold jumps. Goal: deliver time-localised pulses (launch event, influencer drops, limited-edition availability, coordinated PR) when inversion and coherence are simultaneously high, maximising constructive interference. This is implemented by choosing pulse times t_k via the feedback statistic y_n and using sharper κ_τ windows (high cadence contrast).

Phase IV (repeat): series of laser events via adaptive re-pumping. After each threshold jump, coherence and inversion can decay (open-system noise and attention leakage). The evolutive controller alternates:

$$\text{re-pump (restore inversion)} \;\rightarrow\; \text{re-cohere} \;\rightarrow\; \text{pulse (trigger next event)}.$$

This corresponds to maintaining the system near a driven, metastable regime where multiple macroscopic jumps in $\langle N_D\rangle$ are feasible over the horizon.

8.7 Design diagnostics: operational measurement system

The field-theoretic quantities used to define a laser event (Definition 5.3) are not measured directly; they are *diagnosed* through proxies. For the NYC perfume launch, the minimal operational triple is:

1. **Inversion proxy (readiness).** Define a sales-lift estimator $\widehat{I}(t) := \widehat{S}(t)/\widehat{S}_{\mathrm{base}}(t)$ with a declared target $\widehat{I}(t) \geq 10$ over a sustained window. In practice, $\widehat{S}$ comes from retail + ecommerce + attribution, while $\widehat{S}_{\mathrm{base}}$ is estimated from matched controls (holdouts), historical seasonality, or a Bayesian structural time-series model.

2. **Coherence proxy (alignment).** Estimate a coherence-length surrogate $\widehat{\ell_c}(D,t)$ from cross-channel frame alignment: (i) embed creatives and user text into a common semantic space and track their angular dispersion; (ii) compute synchrony/phase-locking of engagement time series across platforms and micro-segments. Higher alignment and tighter phase relations correspond to longer effective coherence.

3. **Gain/threshold proxy (stimulated response).** Track the regional occupation $\widehat{\langle N_D \rangle}(t)$ for a chosen definition of "engagement quantum" (qualified visits, saves, add-to-cart, purchases). A candidate laser event is flagged by a pulse-locked jump

$$\Delta\widehat{\langle N_D \rangle}_k := \widehat{\langle N_D \rangle}(t_k^+) - \widehat{\langle N_D \rangle}(t_k^-) \geq N_{\text{crit}},$$

together with *repeatability*: comparable pulses at similar state $(\widehat{I}, \widehat{\ell_c})$ produce comparable $\Delta\widehat{\langle N_D \rangle}$, whereas off-state pulses do not.

When these three diagnostics align (high inversion, long coherence, and strong pulse response), the model predicts constructive interference and a high likelihood of laser events. When any one fails, pulses are expected to yield mostly "spontaneous" (diffuse, noisy) response rather than coherent gain.

9 Conclusion

The article proposes a QFT-style vocabulary for marketing as a complex system—not because consumers are electrons, but because *fields, symmetries, and quanta* give compact handles on heterogeneity, propagation, and bursty collective response.

On the formal side we described consumers, brands, and media as interacting fields on a configuration space with a gauge-invariance principle that prevents us from mistaking relabelling for dynamics. Contextuality and campaign interference then appear as structural consequences of non- commuting observables and amplitude-level superposition. On the phenomenological side we defined *laser events* as coherent gain threshold crossings for regional number operators: they require readiness (inversion), alignment (coherence), and a perturbation that couples to the aligned mode strongly enough to produce a macroscopic jump in engagement counts, rather than a polite puff of noise.

Finally, we translated the vocabulary into an evolutive campaign design loop for a NYC perfume launch with an explicit 10× inversion target and two practical controls—budget and cadence —closed around measurable diagnostics for inversion, coherence, and pulse response. The intent is not to declare victory for a metaphor, but to offer a principled host language in which interference, thresholds, and scale effects are *first-class* design objects rather than after-the-fact anecdotes.

Acknowledgements

The author thanks colleagues for the (admittedly) long lunch discussions that helped sharpen the exposition.

Author contributions J. J. S. conceived the framework and wrote the manuscript.

Funding information This work received no external funding.

Competing interests The author declares no competing interests.

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