Logic Field Theory: Introduction and Comparison

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Abstract

Logic Field Theory (LFT) is a proposed modification of quantum mechanics that addresses the quantum measurement problem through an objective collapse mechanism grounded in logical consistency. It posits that physical reality is not fundamental but emerges from the constraint of logic on information:

$$\Omega = L(S)$$

where Ω is the set of physically realizable states, S is the space of informationally defined quantum states, and L is a logical constraint operator. Central to LFT is the idea of *logical strain*, a scalar functional $D(\psi)$ that quantifies the internal inconsistency or instability of a quantum state. Collapse occurs only if a state is logically admissible, with realizability given by:

$$P_{\text{realize}}(\psi) = \exp(-\beta D(\psi))$$

where β is a logical inverse temperature parameter. The theory makes a unique and falsifiable prediction: the possibility of *complete measurement failure (a null result)* for states exceeding a critical strain threshold, an effect absent from both standard quantum mechanics and existing collapse models. This paper analyzes LFT's competitive position, philosophical implications, and experimental testability, presenting it as a potential completion—not rejection—of quantum mechanics.

1 Introduction: The Measurement Problem

Quantum mechanics describes the evolution of systems through the deterministic Schrödinger equation von Neumann [1932]. Yet measurement yields definite outcomes, with probabilities given by the Born rule. This discontinuity—the collapse of the wavefunction—has long puzzled physicists Bell [1966]. Logic Field Theory (LFT) enters the conversation as an objective collapse theory: a testable, deterministic proposal that introduces a physically motivated mechanism behind quantum state reduction.

2 Competitive Landscape

LFT competes within the space of interpretations and modifications of quantum mechanics aimed at solving the measurement problem. Table 1 outlines its position.

Table 1: Comparison of major interpretations and collapse models with LFT.

Theory	**QMMod?**	**Collapse Mechanism**	**Key Difference from LFT**
Copenhagen Bohr [1935]	No	Postulated upon measurement	No physical mechanism for collapse is proposed.
Many-Worlds Everett [1957], Wallace [2012]	No	No collapse; all outcomes occur in branching universes	Not falsifiable, as predictions within any single branch are identical to standard QM.
dB-Bohm Bohm [1952]	Yes	Hidden variables are particle-based, guided by a pilot wave	The hidden variables are properties of particles, not the state itself.
CSL Ghirardi et al. [1986], Pearle [1989], Bassi & Ghirardi [2003]	Yes	An external, stochastic noise field induces collapse	Collapse is fundamentally random and mass-dependent, not deterministic and information-dependent.
LFT	Yes	State-dependent logical strain $D(\psi)$ determines realizability	Collapse is deterministic, state-based, and informationally driven.

3 Philosophical Framework of LFT

3.1 Tier 1: Flexibly Deterministic

LFT describes a universe governed by deterministic rules, where outcome probabilities reflect epistemic limitations. The Born rule is reinterpreted as emergent:

$$P_{\mathrm{LFT}}(s_j|\psi) = \exp(-\beta D(\psi)) \cdot \frac{|c_j|^2 \exp(-\beta D(s_j))}{\sum_k |c_k|^2 \exp(-\beta D(s_k))}$$

3.2 Tier 2: State-Based Hidden Variables

Unlike dBB, where hidden variables are particle properties, LFT posits hidden variables ξ as physical instantiation parameters of the entire state ψ.

Analogy: Software on Hardware

- $|\psi\rangle$: The abstract software code.
- Universe: The computational substrate.
- ξ: The precise runtime state of the hardware during execution.

3.3 Tier 3: Epistemic, Not Ontic, Hiding

Where CSL invokes ontological randomness, LFT treats hiddenness as practical inaccessibility due to complexity.

4 Experimental Stakes: Null Measurement as Smoking Gun

LFT predicts that collapse is a threshold-based event:

$$\Pi_{\text{collapse}}(\psi) = \begin{cases} 1 & \text{if } \exp(-\beta D(\psi)) \geq \varepsilon \\ 0 & \text{otherwise} \end{cases}$$

This implies genuine null results when logical strain exceeds a critical threshold. This behavior is fundamentally absent in standard QM and major collapse models.

Experiments on GHZ Greenberger et al. [1989] and W states can test this prediction using superconducting platforms Arute et al. [2019] over 50–100 μs delay intervals. Distinguishing from decoherence requires careful baseline modeling Zurek [2003].

5 Resolving the EPR Paradox

LFT affirms EPR's claim that QM is incomplete Einstein et al. [1935] but replaces the postulate of local realism with a framework of global logical constraint.

Outcomes are not set by local particle properties but by holistic strain across the full state ψ. The hidden variables ξ encode the concrete instantiation of that global state.

Resolution: LFT is *ontologically non-local but dynamically local.* It replaces faster-than-light causal influence with a global, non-causal constraint imposed by the holistic structure of the state's instantiation, ξ.

Reframed Claim: LFT satisfies Einstein's demand for determinism while accepting Bell correlations Bell [1964], Aspect et al. [1982] as arising from non-causal, globally coherent constraints.

6 Conclusion: Completing Quantum Mechanics

LFT retains the full quantum formalism but explains its structure via deeper logical necessity. It offers:

- A deterministic mechanism for collapse.
- A unique, falsifiable prediction (the null result).
- A completion of QM grounded in logic.

What Bohm did with trajectories, and CSL did with randomness, LFT does with logic. If confirmed, LFT would redefine physical law as emergent from logical consistency.

Resources

Project Repository: https://github.com/jdlongmire/Logic_Field_Theory_Gen13

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