Specular Field Theory

Minimal Overview and Weak-Field Prediction

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Abstract

The Specular Field Theory (SFT) introduces a minimal geometric extension in which time possesses an independent informational geometry, sourced by a scalar coherence field. In the regime of small temporal deformation, the theory yields a linear-response structure for scrambling dynamics, providing a parameter-free and falsifiable prediction that can be tested on current quantum hardware. This document presents a concise overview of the core concepts and operational predictions.

1 Conceptual Overview

The SFT is built on a dual-sheet structure:

- the **physical sheet** F_r, where standard quantum evolution occurs;
- the **specular sheet** F_s, a purely temporal manifold equipped with its own informational geometry.

The coherence field $\Phi_s(t_s)$ defines the geometry of F_s. Temporal curvature on this manifold determines how informational quantities evolve, including coherence, scrambling, and regime transitions.

Informational behaviour is a geometric response of the temporal field.

No additional dynamical assumptions are introduced: informational dynamics emerge from the geometry of time.

2 Temporal Curvature and Informational Response

The SFT introduces an effective temporal curvature parameter:

$$A_{\mathrm{SFT}} = \frac{1}{2}\partial_{t_s} \ln |\Phi_s(t_s)|.$$

Small temporal deformation corresponds to the **weak-field regime**, where the informational geometry remains close to symmetric and the response is linear.

This regime is the operational domain relevant for current quantum hardware.

3 Weak-Field Prediction

In the weak-field regime, the scrambling exponent extracted from fidelity decay experiments takes the operational form:

$$\lambda_{\mathrm{eff}} \propto A_{\mathrm{SFT}}\, E_{\mathrm{ent}},$$

where E_{ent} is the entanglement contribution of the circuit.

This leads to a parameter-free prediction:

The ratio of scrambling exponents between two circuit configurations depends only on the ratio of their temporal curvature and entanglement.

Once a single reference experiment fixes the global scale, all subsequent predictions are parameter-free.

4 Minimal Experimental Test

Two circuit configurations are required:

- Setup 1: low entanglement, small temporal deformation;
- Setup 2: higher entanglement, larger temporal deformation.

For the purpose of this test, A and E_{ent} are treated as effective parameters that characterize the scrambling regime of the circuit:

- A is associated with the depth and gate structure of the circuit;
- E_{ent} is associated with the amount of entanglement generated.

The test does not require absolute calibration of these parameters: only their relative values between the two regimes are needed.

The theory predicts:

$$\frac{\lambda_{\text{eff},2}}{\lambda_{\text{eff},1}} \simeq \frac{A_2 E_{\text{ent},2}}{A_1 E_{\text{ent},1}}$$

in the weak-field limit ($A_i \ll 1/2$). The full expression, including the curvature-dependent factor, is reserved for collaborative development.

No additional parameters appear after calibration. Any deviation from this ratio would challenge the weak-field structure of the SFT.

5 Structural Correspondence with Known Phenomena

The linear-response structure mirrors the behaviour of fidelity decay under small perturbations (Loschmidt echo), while remaining formally independent of the specific quantum mechanical framework used to describe such decays.

This correspondence provides a physically transparent interpretation of the weak-field regime: temporal curvature acts as an informational perturbation.

6 Summary

The SFT provides:

- a minimal geometric extension in which time carries informational curvature;
- a weak-field regime with a parameter-free and falsifiable prediction;
- a clear operational pathway for testing on current quantum hardware.

7 Collaboration

This document is intended as a concise introduction for collaborative exploration. I am seeking experimental and academic partnerships to:

- validate the weak-field prediction on current quantum hardware;

- explore the strong-field regime through cross-analysis of existing quantum datasets;
- co-develop the full mathematical formulation of the framework.

For collaboration inquiries, please contact:

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Collaboration is warmly welcomed at any level, from conceptual discussion to joint experimental design.