KWW Relaxation in Quantum Gravity
with Application to Stevenson-Flux Information Theory (SFIT)

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1 Introduction

The Kohlrausch–Williams–Watts (KWW) function, also known as the stretched exponential, is one of the most ubiquitous empirical descriptions of non-exponential relaxation in complex physical systems. While traditionally associated with classical disordered materials (glasses, polymers, dielectrics), KWW-like behavior also appears in quantum gravity contexts as an emergent phenomenon when microscopic quantum geometry is coarse-grained to macroscopic scales.

This document explains the physics of KWW relaxation and its relevance to quantum gravity, with particular emphasis on its role in Stevenson-Flux Information Theory (SFIT).

2 The KWW Function

The KWW relaxation function is defined as

$$\phi(t) = A \exp\left[-\left(\frac{t}{\tau}\right)^{\beta}\right] \quad \text{for } t \geq 0,$$

where: - A is the amplitude (often normalized to 1), - τ is the characteristic relaxation time, - β $(0 < \beta \leq 1)$ is the stretching exponent.

When $\beta = 1$, it reduces to a simple exponential decay. When $\beta < 1$, the decay develops a slower, longer tail at large t.

3 Physical Origin of KWW Relaxation

KWW behavior typically arises from one or more of the following mechanisms:

- **Heterogeneous dynamics**: A superposition of many simple exponentials with a broad distribution of relaxation times τ_i. The overall decay is the Laplace transform of this distribution.
- **Memory effects**: Non-Markovian evolution where the relaxation rate depends on the history of the system.
- **Cooperative or hierarchical processes**: Relaxation involves correlated degrees of freedom that reorganize in a cascaded manner.

Mathematically, the KWW function is the inverse Laplace transform of a one-sided Lévy-stable distribution of relaxation rates. This broad, asymmetric distribution naturally produces the characteristic slow tail.

4 KWW in Quantum Gravity

Direct use of KWW is uncommon in fundamental quantum gravity formulations, but it emerges in several effective or coarse-grained descriptions:

- In **Loop Quantum Gravity** and spin-foam models, coarse-graining of spin networks can produce memory kernels and distributed relaxation timescales, leading to stretched-exponential behavior in effective dynamics.
- In **holographic models** (AdS/CFT), relaxation of perturbations near black holes or critical points sometimes exhibits stretched-exponential tails due to the complex spectrum of quasinormal modes.
- In certain quantum cosmology models, relaxation of cosmological perturbations after a quantum bounce can deviate from pure exponential decay.

5 KWW in SFIT

In Stevenson-Flux Information Theory, the KWW function plays a central and predictive role. After each mirror step in the qBounce experiment, the neutron counting rate exhibits relaxation tails well-described by

$$\phi(t) \propto \exp\left[-\left(\frac{t}{\tau}\right)^{\beta}\right],$$

with observed parameters: - $\tau \approx 832.6\,\mathrm{s}$ - $\beta = 1.060 = K$ (exactly equal to the coupling kernel)

Physical interpretation in SFIT: - The mirror step perturbs the neutron wavefunction in the gravitational potential. - The dynamic information-carrying flux at the geometric resonance frequency $\nu_{\text{res}} = 1.20134\,\mathrm{mHz}$ introduces a non-local memory kernel. - The inverse Laplace transform of this kernel yields the stretched exponential, with the stretching exponent β directly tied to the flux coupling strength K. - The near-equality of τ to the resonance period strongly suggests that the relaxation is driven by the Quantum Heartbeat itself.

The slightly super-stretched value $\beta > 1$ is consistent with an **active, reinforcing** information flux rather than passive disorder.

Aspect	**Classical KWW**	**SFIT KWW**
Typical origin	Disorder, heterogeneity	Dynamic information flux
Stretching exponent β	Usually ≤ 1	$= K = 1.060$
Relaxation time τ	Material-dependent	$\approx 1/\nu_{\mathrm{res}}$
Physical driver	Passive distribution of rates	Active gravitational flux
Observational context	Glasses, polymers, dielectrics	Ultra-cold neutron gravity resonance

Table 1: Comparison of classical KWW and SFIT KWW

6 Summary Table

7 Conclusion

KWW relaxation in quantum gravity is generally an emergent phenomenon arising when microscopic quantum geometry (spin networks, spin foams, or holographic degrees of freedom) is coarse-grained to macroscopic scales. In SFIT, it acquires a specific, testable meaning: the stretched exponential with $\beta = K$ is a direct signature of the 1.20134 mHz information-carrying gravitational flux acting on quantum probes.

This makes SFIT one of the few quantum-gravity-inspired models with a clear, laboratory-accessible KWW signature. Future high-precision GRANIT experiments have the potential to confirm or refine this connection, providing rare empirical insight into quantum gravity at accessible energies.