On Black Holes and Galactic Structure

Letter from the Ongoing Work: August 2025

I hope this letter finds you well. I am writing to share a line of thought that extends from my recent work on the *Decoherence as First Principle* framework, with a focus on the long-standing puzzle of the relationship between supermassive black holes (SMBHs) and their host galaxies.

As you know, the empirical evidence is clear: black hole mass correlates tightly with bulge stellar velocity dispersion (the M–σ relation), reasonably with bulge mass, and in some cases with halo properties such as circular velocity. This has often been interpreted in terms of coevolution and AGN feedback. Yet the causal mechanisms remain debated, especially given the vast spatial scales involved and the presence of outliers such as pseudobulges.

Within the decoherence-bootstrap framework, these observations take on a different character. If we treat gravity as the first stabilized pointer basis, then both SMBH growth and bulge dispersion are natural co-products of the same early gravitational decoherence events. In this view:

- **The tight M–σ relation** reflects two parallel registers of the same gravitational potential depth—the decoherence budget of the nucleus—rather than a purely feedback-regulated equilibrium.
- **Links to halo properties** arise because the halo concentration and circular velocity encode the earliest gravitational pointer-state architecture, predating electromagnetic stabilization. Black hole and host are thus co-imprinted by the same gravitationally classical scaffolding.
- **Scatter from pseudobulges** emerges naturally: systems whose late-time (EM-era) assembly dominates have weaker ties to the early gravitational framework, so they deviate from the tight relation established in classical bulges.
- **High-redshift overmassive black holes** may be understood as a timing effect. During epochs of extremely short collapse length, SMBHs could outpace electromagnetic-anchored stellar assembly, with the apparent ratio later balanced as EM-era processes caught up (Bañados *et al.*, 2018; Inayoshi, Visbal and Haiman, 2020; López-Honorez *et al.*, 2023).

This interpretation reframes AGN feedback not as the origin of the scaling relations but as a regulator of scatter. The scaling itself is inherited from the gravitational pointer basis, a kind of cosmological memory embedded in early decoherence dynamics.

Several testable implications follow:

1. At fixed σ, SMBH mass should correlate with halo concentration or inner density slope—hard to explain with feedback alone.
2. Environment (e.g., cosmic web nodes) should leave residual imprints: galaxies formed in deeper early gravitational wells should host proportionally larger SMBHs.
3. Redshift evolution of $M_{BH}/M_{\star}$ ratios should largely vanish when conditioning on gravitational-depth proxies, rather than EM-visible stellar mass.

The Dark Epoch as Horizon: Why Early SMBHs Aren't a Mystery

Much attention has been given to the discovery of billion-solar-mass SMBHs less than a billion years after the Big Bang. These are often portrayed as a profound puzzle, since their growth rates in the EM-era appear inconsistent with the short time available. In the decoherence-bootstrap framework, however, the mystery dissolves. Before the stabilization of the electromagnetic pointer basis, conservation laws as we understand them were not yet enforced. Gravity alone provided a classical scaffold, and SMBHs emerged immediately as the natural outcome of failed experiments in stability—runaway gravitational collapse in a universe without electromagnetic feedback. Only with the arrival of the EM-era did regulatory mechanisms such as radiation pressure and winds begin to restrain their growth. Just as the horizon of a black hole terminates decoherence by sending collapse length to infinity, the dark epoch of the early universe reflects its mirror: collapse length vanishingly short, decoherence hyperactive, conservation not yet fixed. In this symmetry, early SMBHs are not anomalies but necessities—the natural boundary conditions of a universe learning its laws.

The Universe Learns Its Own Laws

This idea resonates with a broader perspective now emerging at the intersection of cosmology and quantum information. In the earliest epochs, conditions were undifferentiated—constants and couplings (c, G, α) were not yet fixed or meaningful. With each *frame* of cosmic evolution, quantum-gravitational interactions selected configurations that maximized stability and persistence of classical reality. Physical constants may thus have *locked in* as the universe underwent a form of symmetry breaking and self-organization, settling into rules that support structure, chemistry, and memory. In this sense, the apparent fine-tuning of the Standard Model and cosmological constants is not accidental, but the outcome of a learning-like process: classical branches persist because those parameter sets allow durable records and observers. This echoes Smolin's **cosmological natural selection** (Smolin, 1997), Wheeler's **it-from-bit** (Wheeler, 1990), Lloyd's **quantum universe** (Lloyd, 2006), and more recent proposals in emergent-law physics (Hardy, 2001; Chiribella, D'Ariano and Perinotti, 2011): laws themselves as outcomes, not inputs.

Infalling matter near a black hole undergoes the strongest possible classicalization. In terms of the decoherence framework, this corresponds to a collapse length approaching zero. At the event horizon, however, the situation changes qualitatively: the collapse length diverges, and decoherence events no longer occur. To an external observer, this manifests as matter appearing to freeze at the horizon due to extreme gravitational time dilation. From the perspective of the infalling system, individuality is erased as all mass-energy contributes to a single unresolved pointer state at the center of mass. In this sense, the Big Bang can be regarded as the initiation of decoherence, while black holes represent its termination. The sequence of collapse events between these two extremes constitutes what we conventionally describe as time.

Note on Time as a Parameter Near Horizons

In flat space or laboratory systems, Lindblad evolution is written with respect to coordinate time t. Near an event horizon, however, time becomes a treacherous parameter. From the perspective of a distant observer, infalling clocks slow asymptotically, never crossing the horizon; from the perspective of the infaller, proper time ticks normally until termination at the singularity. These two descriptions cannot be reconciled with a single universal t. What remains well-defined is the progression along a worldline (proper time τ for massive particles, affine parameter λ for photons). Thus, when describing decoherence in strong-gravity regimes, it is more natural to write Lindblad-type evolution against τ or λ. Close to horizons, time in the global sense loses meaning as a smooth parameter; only trajectory-based evolution remains physically coherent.

I am under no illusion that these ideas solve the coevolution puzzle outright, but they may offer a new perspective: that the SMBH–galaxy connection is, at root, a record of the universe's first successful decoherence channel—gravity—and the structures that stabilized under it.

I would welcome your thoughts, criticisms, or pointers toward related work.

With best regards,

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