The Hubble Tension as Invariant Mismatch Across Cosmological Descriptive Regimes

A Quantum Collapse Geometry Interpretation of the Local Distance Network

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Abstract

Recent work by the H_0 Distance Network (H0DN) collaboration constructs a covariance-weighted network of local distance indicators, achieving a $\sim 1\%$ precision determination of the Hubble constant [1]. The resulting value remains in strong statistical tension with early-Universe inferences within ΛCDM. We propose a structural reinterpretation of this tension within the framework of Quantum Collapse Geometry (QCG). In this perspective, the local determination of H_0 arises as an invariant family across multiple admissible observational pathways, while early-Universe inferences correspond to a model-dependent projection from a distinct descriptive regime. The observed discrepancy is interpreted not primarily as a failure of local measurement or a simple parameter shift, but as a mismatch in invariant structure across cosmological admissibility layers. This framing preserves all empirical results while suggesting new directions for interpreting cosmological tensions as regime-dependent phenomena.

1 Introduction

The determination of the Hubble constant H_0 remains one of the central problems in modern cosmology. Over the past decade, increasingly precise local measurements have diverged significantly from values inferred from early-Universe observations under the ΛCDM model. This discrepancy, known as the *Hubble tension*, now exceeds conventional statistical thresholds and has persisted across multiple independent analyses.

The recent H_0 Distance Network (H0DN) collaboration introduces a network-based approach to local distance determination, combining multiple overlapping measurement pathways with explicit covariance treatment. This framework achieves sub-percent precision while demonstrating robustness to the inclusion or exclusion of individual indicators.

The persistence of the tension under this expanded and redundant measurement structure motivates a reconsideration of its interpretation.

2 The Local Distance Network as a Robust Observational Sector

Traditional distance-ladder approaches rely on a sequence of calibration steps linking geometric anchors to cosmological tracers. The H0DN framework generalizes this structure into a *network* of partially overlapping pathways[1], incorporating:

- multiple geometric anchors (parallax, masers, eclipsing binaries),
- multiple primary distance indicators (Cepheids, TRGB, Miras),

- multiple secondary tracers (SNe Ia, SNe II, Tully–Fisher, SBF),
- explicit covariance treatment across shared calibration sources.

This architecture enables:

- redundancy across independent calibration routes,
- robustness through leave-one-out analysis,
- covariance-weighted combination of all available data.

The key empirical result is that diverse measurement pathways converge to a consistent local value of H_0[1], indicating the presence of a stable observational structure that is not reducible to any single method. In particular, this stability is observed at the level of the combined network rather than any individual measurement pathway.

3 QCG Framework: Selection, Admissibility, and Invariant Structure

Quantum Collapse Geometry (QCG) provides a generative ontology in which physical structure arises through selection under constraint. The framework is defined by:

- a relational configuration space Σ,
- a collapse-selection operator $\Phi : \Sigma \to \Sigma$,
- a projection $P : \Sigma \to \mathcal{O}$ onto observable structure.

Observable quantities correspond to configurations that persist under repeated application of Φ, forming invariant sectors:

$$\mathrm{Fix}(\Phi) = \{x \in \Sigma \mid \Phi(x) = x\}.$$

Within this framework:

- admissibility defines which configurations can persist,
- collapse eliminates incompatible configurations,
- invariant families represent stable structure across admissible dynamics.

Different descriptive pathways may correspond to distinct collapse classes, yet yield identical observable structure when they belong to the same invariant family.

4 Mapping the Distance Network to QCG Structure

The Local Distance Network admits a natural interpretation within the QCG framework:

Cosmological Structure	**QCG Interpretation**
Distance network configuration	Relational configuration space Σ
Measurement pathways	Admissible collapse classes
Covariance-weighted solution	Descriptive projection P
Consistent local H_0 value	Invariant family across collapse classes

In this interpretation:

- each measurement pathway represents an admissible route through configuration space,
- covariance structure encodes relational constraints between configurations,
- the convergence of distinct pathways indicates the presence of a collapse-stable invariant sector.

Thus, the locally measured value of H_0 is not merely an estimate, but a persistent structure arising across multiple admissible descriptive realizations.

5 Diagrammatic Interpretation

The structural correspondence between the Local Distance Network and the QCG framework may be summarized schematically as follows:

Cosmological Description Layer

Distance Network Configurations (multiple pathways)
$\downarrow$
Covariance + Consistency Constraints
$\downarrow$
Stable Local Value of H_0

Structural correspondence under admissibility
QCG Interpretation Layer

Relational Configuration Space Σ
$\downarrow$ Φ (admissibility / collapse-selection)
Invariant Sector $\mathrm{Fix}(\Phi)$
$\downarrow$ P (descriptive projection)
Observable H_0

Figure 1: Schematic correspondence between the Local Distance Network and the QCG framework. Multiple measurement pathways define a relational configuration space whose covariance structure imposes constraints. The resulting stable value of H_0 is interpreted as an invariant sector under admissible collapse dynamics, projected into observable form.

6 The Hubble Tension as Cross-Regime Invariant Mismatch

Standard cosmological interpretation assumes that local and early-Universe determinations of H_0 correspond to the same underlying parameter.

Within QCG, this assumption is nontrivial.

Early-Universe inferences rely on a model-dependent compression of global cosmological structure into a small set of parameters. This process corresponds to a projection from a distinct descriptive regime, potentially separated from the local observational sector by an admissibility boundary (epistemic horizon).

From this perspective:

- the local distance network defines a late-time invariant family,
- early-Universe inference defines a projected invariant under a different constraint structure,
- the tension arises from a mismatch between these invariant structures.

The discrepancy is therefore interpreted as:

$$\text{Hubble tension} \sim \text{failure of invariant transport across regimes.}$$

This interpretation does not require modifying local measurements or introducing specific new parameters, but instead identifies a structural limitation in the assumption that invariant quantities are preserved across cosmological descriptive layers.

7 Implications and Testable Consequences

This framework suggests several qualitative implications:

- Further diversification of local measurement pathways should continue to yield consistent H_0 values within the local sector.
- Attempts to resolve the tension purely through local systematic corrections should become increasingly constrained.
- Modifications to early-Universe models may be most effective when they alter the effective projection between regimes.
- Similar tensions may appear in other cosmological parameters where cross-regime projection is assumed.

More broadly, cosmological tensions may reflect structural boundaries between descriptive regimes rather than isolated discrepancies in measurement or modeling.

8 Conclusion

The Local Distance Network provides strong evidence that the locally measured value of H_0 represents a stable and robust observational structure. Within the QCG framework, this stability is naturally interpreted as an invariant family across admissible collapse classes.

The persistence of the Hubble tension under increasingly redundant local measurements suggests that the discrepancy does not arise solely from experimental limitations or simple parameter shifts. Instead, it may reflect a deeper structural issue: the assumption that invariant quantities can be transported unchanged across distinct cosmological descriptive regimes.

Quantum Collapse Geometry provides a conceptual framework in which such mismatches are expected, arising from the generative distinction between admissibility, selection, and projection.

This perspective preserves all empirical results while reframing the interpretation of cosmological tensions as regime-dependent phenomena, opening new avenues for both theoretical and observational investigation.

References

[1] Stefano Casertano et al. "The Local Distance Network: A community consensus report on the measurement of the Hubble constant at 1% precision". In: *Astronomy & Astrophysics* 708 (2026), A166.