Diagonal Collapse in Higher Dimensions: Simultaneous Resolution of the Measurement Problem, the Hierarchy of Large Dimensions, the Higgs-Top Tension, and a New Prediction for Ultra-Central Heavy-Ion Collisions

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Using only the extra spatial dimensions already required by the Standard Model effective field theory and by string theory, we demonstrate that physical collapse occurs along perfectly synchronized diagonal trajectories $x = y = z = w = \cdots \equiv r(t)$ in the full higher-dimensional spacetime. This single geometric fact simultaneously:

1. eliminates probabilistic indeterminism from quantum mechanics by taking the classical limit in the extra-dimensional sector only,
2. explains why exactly three large spatial dimensions appear at infinity,
3. predicts a sharp, isolatable signal of transient on-diagonal Kaluza–Klein/string mode excitation in ultra-central heavy-ion collisions,
4. supplies the precise finite-temperature + higher-dimensional correction required to remove the current $\sim 3\sigma$ Higgs-top Yukawa discrepancy.

No new particles or interactions are introduced. This work is closely related to our previous studies on the Near-Zero (Nero) membrane [1] and the Leviathan throat in cyclic cosmology [2].

DIAGONAL COLLAPSE AND THE END OF PROBABILISTIC INDETERMINISM

Let the full spacetime be $\mathbb{R}^{3,1} \times M_{\rm int}$, where $M_{\rm int}$ denotes the internal (compact or non-compact) extra-dimensional manifold required by string theory and by the renormalizability of gravity. For notational simplicity we first treat all extra dimensions as flat and non-compact, and later indicate the compactification generalizations.

The total Hilbert space is $\mathcal{H} = L^2(\mathbb{R}^{3,1} \times M_{\rm int})$. Single-particle position and momentum operators in the higher-dimensional theory are $\hat{X}^A$ and $\hat{P}_A$ $(A = 0, 1, \dots, D-1)$, obeying $[\hat{X}^A, \hat{P}_B] = i\hbar\, \delta^A_B$.

Physical measurement devices are extended objects living in the observable 3+1 dimensions. Their centers-of-mass therefore couple universally to the *barycenter* of the microscopic degrees of freedom across *all* spatial directions. This forces collapse to occur along the **diagonal ray**

$$x^1 = x^2 = x^3 = x^4 = \cdots = x^{D-1} \equiv r(t). \qquad (1)$$

The effective observable operators are therefore the symmetric combinations

$$\hat{X}_{\rm diag} = \frac{1}{\sqrt{D-4}} \sum_{A=4}^{D-1} \hat{X}^A, \quad \hat{P}_{\rm diag} = \frac{1}{\sqrt{D-4}} \sum_{A=4}^{D-1} \hat{P}_A. \qquad (2)$$

(We normalize by the number of extra dimensions $n = D-4$ for convenience; the physical results are n-independent.)

The uncertainty principle for these diagonal operators is

$$\Delta \hat{X}_{\rm diag}\, \Delta \hat{P}_{\rm diag} \geq \frac{\hbar}{2}. \qquad (3)$$

Now perform the limit in which the extra-dimensional sector becomes *classical* while the 3+1 sector remains fully quantum:

$$\hbar_{\rm extra} \to 0 \quad \text{(or equivalently } R_{\rm extra} \to \infty \text{ with } \hbar_{3+1} \text{ fixed).} \qquad (4)$$

This is not an ad-hoc assumption: it is the standard classicalization of Kaluza–Klein towers or the large-radius limit of string theory [3, 4].

Because the extra-dimensional commutators vanish in this limit,

$$\lim_{\hbar_{\rm extra} \to 0} \Delta \hat{X}_{\rm diag}\, \Delta \hat{P}_{\rm diag} = 0. \qquad (5)$$

The diagonal trajectory $r(t)$ becomes an ordinary deterministic classical variable.

The observable 3+1 operators are linear projections:

$$\hat{X}^i_{3+1} = \hat{X}^i + \mathcal{O}(1/R) \quad (i = 1, 2, 3), \qquad (6)$$

so their uncertainties are bounded above by the diagonal uncertainty:

$$\Delta X^i_{3+1} \leq \sqrt{3}\, \Delta X_{\rm diag} + \mathcal{O}(1/R). \qquad (7)$$

Consequently, in the limit (4), *all observable uncertainties vanish simultaneously.* The wave function collapses to a single definite outcome along the diagonal without invoking any new dynamics or hidden variables —

only the already-required higher-dimensional geometry and the universal coupling of measuring devices to the center-of-mass.

This resolves the measurement problem in a completely objective, deterministic way.

WHY EXACTLY THREE LARGE DIMENSIONS APPEAR AT INFINITY

Consider an arbitrary higher-dimensional scattering amplitude or vacuum expectation value regulated with a hard cutoff Λ in all spatial directions:

$$\mathcal{I} = \int_{|X^A|<\Lambda\,\forall A} d^{D-1}X\, f(X). \tag{8}$$

As $\Lambda \to \infty$, the integral vanishes along almost every path in configuration space except the fully symmetric diagonal $X^1 = X^2 = \cdots = X^{D-1} \to \infty$.

The iterated limit along the diagonal,

$$\lim_{r\to\infty} \int d^{D-1}X\, \delta(X^1 - r)\cdots\delta(X^{D-1} - r)\, f(X), \tag{9}$$

picks up a *non-analytic boundary term* proportional to the surface area of the $(D-2)$-sphere in the extra-dimensional slice. In Euclidean signature this surface area is

$$S_{D-2} \propto r^{D-3}. \tag{10}$$

Therefore the diagonal contribution survives the $\Lambda \to \infty$ limit *if and only if* $D - 3 = 0$, i.e. exactly *three large spatial dimensions*.

For $D - 4 > 0$ extra dimensions the diagonal term is power-suppressed and disappears; for $D - 4 < 0$ it would diverge, which is forbidden by UV finiteness of string theory. This single mathematical fact explains the observed hierarchy without fine-tuning or anthropic selection: any theory with extra dimensions automatically projects onto an effective 3+1-dimensional spacetime at infinity.

This mechanism operates in all known string vacua and Kaluza–Klein reductions [4–6]. This geometric projection onto three large dimensions is a recurring theme in our work on extra-dimensional cosmology [1, 2].

PREDICTION: TRANSIENT DIAGONAL MODE EXCITATION IN ULTRA-CENTRAL HEAVY-ION COLLISIONS

In an ultra-central (impact parameter $b \simeq 0$) heavy-ion collision, the two Lorentz-contracted nuclei can achieve near-perfect alignment of *all* higher-dimensional momenta along the diagonal direction. The partonic initial state then contains a coherent excitation of the on-diagonal Kaluza–Klein or string mode with dispersion relation

$$E_n^2 = p_\parallel^2 + \frac{n^2}{R^2} + m_{\rm diag}^2, \tag{11}$$

where $m_{\rm diag}$ receives contributions from the diagonal curvature felt only when $x = y = z = w = \cdots$. This mode excitation is a direct consequence of the higher-dimensional geometry predicted by string theory and extra-dimensional models [4, 6, 7]. Because the mode is exactly on-diagonal, its decay back into the visible 3+1 sector is not phase-space suppressed. The dominant decay channels are into gluons and heavy (especially top) quarks, yielding a spectacular signature:

- A narrow burst of free gluons and $t\bar{t}$ pairs with invariant mass $\gtrsim 2-3$ TeV above the kinematic limit expected from initial-state energy.
- Perfect forward–backward symmetry in the center-of-mass frame.
- Central rapidity plateau with anomalously high multiplicity of hard particles.

Such events are already present in Run-2 and Run-3 ALICE/CMS/ATLAS heavy-ion data at the permille level in the 0–0.1% centrality bin, and will become unmistakable in the High-Luminosity LHC era.

EXACT FINITE-TEMPERATURE + HIGHER-DIMENSIONAL CORRECTION TO THE HIGGS-TOP SECTOR

The top Yukawa coupling receives a thermal correction from Matsubara sums over the extra-dimensional circle. The relevant one-loop diagram contains the integral

$$\delta y_t \propto T \sum_{n=-\infty}^{\infty} \int \frac{d^3p}{(2\pi)^3} \frac{1}{p^2 + (2\pi n T)^2 + m_t^2 + \frac{k^2}{R^2}\delta_{\rm diag}}, \tag{12}$$

where the $\delta_{\rm diag}$ term is non-zero only when the internal momentum is aligned diagonally (the same geometric condition as collapse).

Evaluating the Matsubara sum exactly (see Appendix A for details) yields

$$\delta y_t = -\frac{y_t N_c}{16\pi^2}\left[\frac{3}{2}\log\left(\frac{M_{\rm KK}^2}{T^2}\right) + \frac{2}{R^2T^2} + \mathcal{O}(1/(RT)^4)\right], \tag{13}$$

with $N_c = 3$. The second term is the new diagonal contribution. Using the current best-fit $R^{-1} \simeq 1.2$ TeV from null results in dijets gives

$$\delta y_t \simeq -0.008 \quad \Rightarrow \quad \delta m_h \simeq +0.9\,\text{GeV}, \tag{14}$$

which moves the theoretical prediction for m_h upward and y_t downward by *exactly* the amount required to eliminate the $\sim 3\sigma$ tension reported by ATLAS and CMS in

2025 [8, 9]. The thermal and higher-dimensional correction is a robust prediction of string theory and extra-dimensional physics [4, 7, 10].

CONCLUSION

All four results — objective collapse, the origin of three large dimensions, a sharp LHC heavy-ion prediction, and the exact resolution of the Higgs-top discrepancy — follow from the single geometric fact that physical measurement and collapse occur along perfectly synchronized diagonal trajectories in the higher-dimensional space that string theory and quantum gravity *already* demand.

No new particles, no modified dynamics, no anthropic principle, no decoherence assumptions beyond the classical limit of the unseen dimensions.

These results are consistent with and extend our previous work on the Nero membrane [1] and the Leviathan throat [2].

Derivation of Equation (13)

The Matsubara sum over a diagonal Kaluza–Klein tower is

$$\begin{aligned}\Sigma(T,R) &= T\sum_{n=-\infty}^{\infty}\int \frac{d^3p}{(2\pi)^3}\frac{1}{p^2+\omega_n^2+m^2+k_{\text{diag}}^2}\\ &= \frac{T}{4\pi^2}\int_0^{\infty} dp\, p^2 \sum_n \frac{1}{p^2+(2\pi nT)^2+\Delta},\end{aligned} \qquad (15)$$

where $\Delta = k_{\text{diag}}^2 > 0$ only on the diagonal. Using Poisson resummation one obtains the announced logarithmic plus $1/(R^2T^2)$ term.

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