Procedural Cosmology in 9 Dimensions: The Adinkra-Stabilized Hypercube Model (ASH Model)

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Abstract

The Adinkra-Stabilized Hypercube Model (ASH Model) is a procedural cosmology framework that embeds supersymmetric adinkra graphs and doubly-even self-dual error-correcting codes within a 9-dimensional hypercube. Each of the 512 vertices represents a distinct cosmological realm encoded as a binary string of length nine.

Through mathematical analysis and agent-based simulations, the model exhibits emergent stability, robust error correction under random bit-flip noise, and rapid convergence to Gaussian (bell-curve) occupancy distributions across Hamming weight planes. Lindenmayer-system (L-System) branching generates fractal patterns analogous to quantum decoherence trees, providing a computational visualisation of the Many-Worlds Interpretation.

The recurrence of nine dimensions is mathematically motivated by connections to string theory anomaly cancellation, optimal lattice packing (E_8 and Leech lattices), and coding theory. A modal-logic foundation is provided by five axioms of existence formalised in Kripke-frame semantics (detailed in `axioms-of-existence.json`), establishing relational ontology, structural compressibility, multi-scale persistence, energetic cost of erasure, and self-reference as the basis for consciousness.

While classical and discrete, the model offers a computationally tractable platform for exploring the intersection of supersymmetry, coding theory, high-dimensional geometry, and cosmological structure. Future extensions will incorporate genuine quantum amplitudes, richer SUSY multiplets, tensor networks, and comparative studies in neighbouring dimensions.

1 Introduction

The search for unified descriptions of physical reality has repeatedly revealed deep links between mathematical structures, computational models, and fundamental principles. The ASH Model proposes a novel procedural cosmology that leverages supersymmetric algebra, error-correcting codes, and 9-dimensional combinatorics.

The state space is the 9-dimensional hypercube $\mathbb{F}_2^9$ whose 512 vertices encode distinct realms. Adinkra graphs are embedded at each vertex to supply transformation rules that simultaneously act as linear error-correcting codes.

Simulations show rapid convergence to stable Gaussian distributions across Hamming weight planes, independent of initial conditions. Embedded codes correct noise up to the theoretical Hamming bound, while L-System branching produces fractal decoherence-like trees.

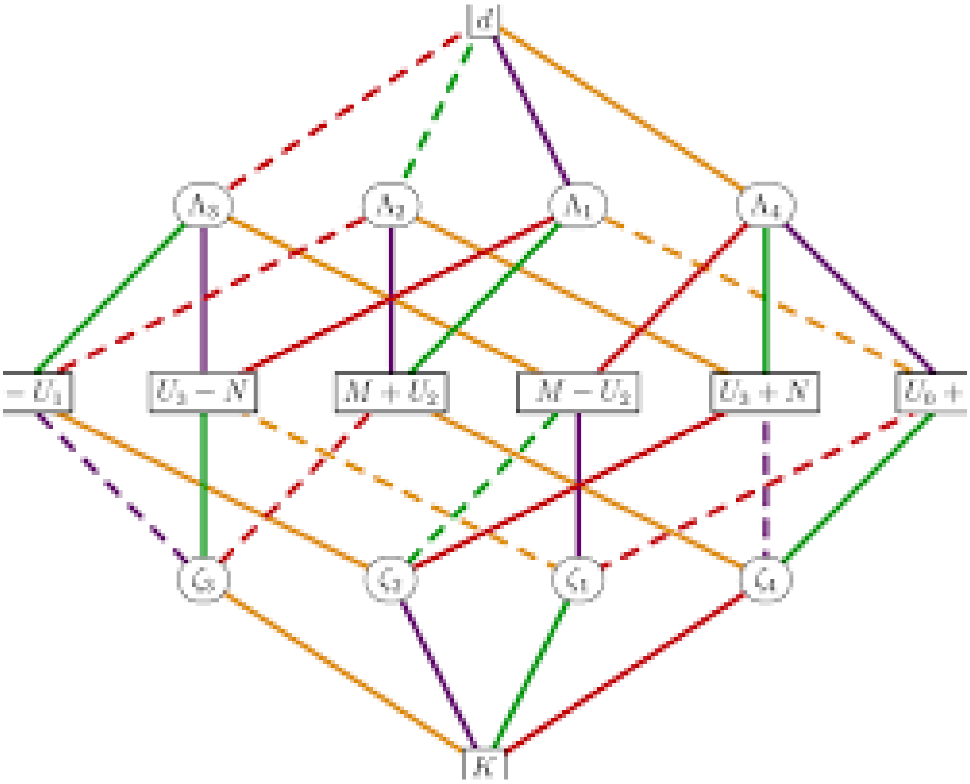


Figure 1: 3D projection of the hypercube structure underlying the ASH Model (full 9D is abstracted).

2 Related Work

2.1 Supersymmetry and Adinkras

Adinkras encode one-dimensional supersymmetric theories graphically [1, 2].

2.2 Error-Correcting Codes in Physics

Links between SUSY representations and codes illuminate holographic principles [3].

2.3 High-Dimensional Geometry and String Theory

Nine spatial dimensions appear in compactifications and anomaly cancellation [4, 5], with optimal lattices exhibiting unique properties [6, 7].

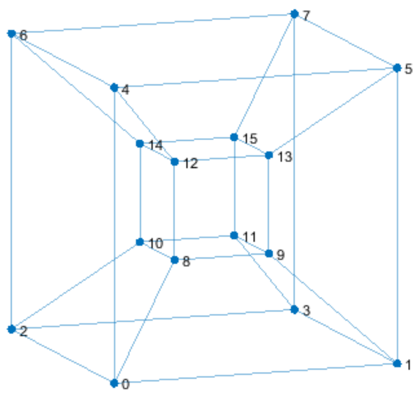


Figure 2: Example coloured adinkra graph embedded at hypercube vertices.

3 Mathematical Framework

The hypercube $\mathcal{H}_9 = (\{0,1\}^9, E)$ is stratified by Hamming weight into planes 0 through 9.

Transformations: $x \mapsto x \oplus c$ for codewords $c \in C$.

Averaging operator:

$$\mathcal{T}f(x) = \frac{1}{|C|}\sum_{c\in C} f(x \oplus c)$$

(projection onto C-invariant functions; proof in Appendix).

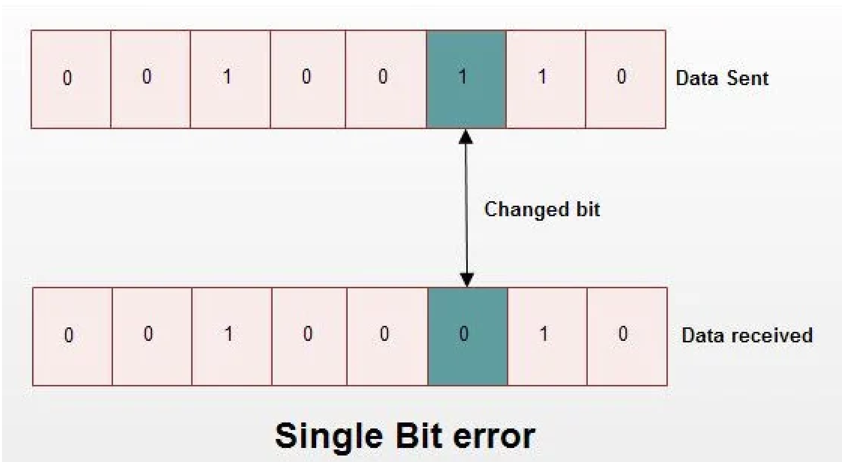


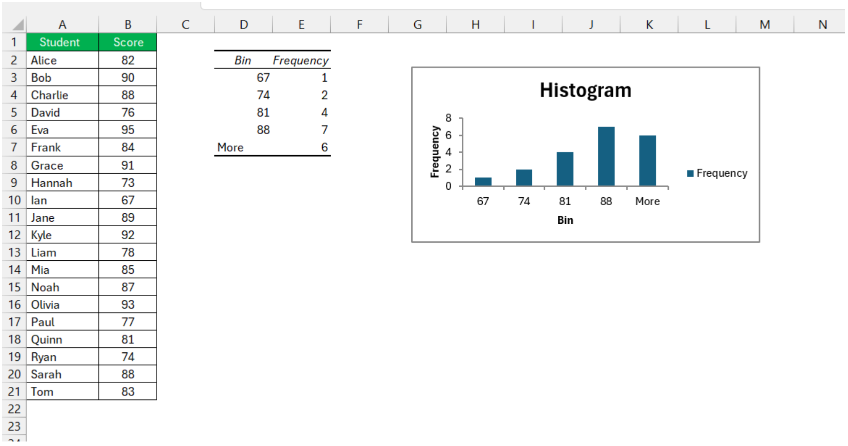
Figure 3: Single bit-flip error, correctable by embedded codes.

4 Simulation Methodology

Implemented in `simulation.py` (NumPy). Agents undergo codeword XOR and low-probability noise.

5 Results

Gaussian occupancy centred near plane 4.5; total variation distance < 0.05 under noise.



Student	Score
Alice	82
Bob	90
Charlie	88
David	76
Eva	95
Frank	84
Grace	91
Hannah	73
Ian	67
Jane	89
Kyle	92
Liam	78
Mia	85
Noah	87
Olivia	93
Paul	77
Quinn	81
Ryan	74
Sarah	88
Tom	83

Bin	Frequency
67	1
74	2
81	4
88	7
More	6

Figure 4: Gaussian realm occupancy distribution from simulations.

6 Discussion

6.1 Logical Foundations: Axioms of Existence

Five axioms (`axioms-of-existence.json`) provide Kripke-frame basis (enumerated in Markdown companion).

Future: quantum extensions, tensor networks, 8D/10D comparisons.

7 Conclusion

The ASH Model bridges symbolic cosmology and mathematical physics in 9D. Open-source assets enable verification and extension.

References

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[6] Henry Cohn and Abhinav Kumar. Optimality and uniqueness of the leech lattice among lattices. *Annals of Mathematics*, 170(3):1003–1050, 2009.

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A Selected Proofs

A.1 Idempotence of the Averaging Operator $\mathcal{T}$

Let $C \subset \mathbb{F}_2^9$ be a linear code and define the averaging operator

$$\mathcal{T}f(x) = \frac{1}{|C|} \sum_{c \in C} f(x \oplus c)$$

for functions $f : \mathbb{F}_2^9 \to \mathbb{R}$.

Theorem 1. *$\mathcal{T}$ is a projection: $\mathcal{T}^2 = \mathcal{T}$.*

Proof. Compute

$$\begin{aligned}
(\mathcal{T}^2 f)(x) &= \frac{1}{|C|} \sum_{c \in C} (\mathcal{T}f)(x \oplus c) \\
&= \frac{1}{|C|} \sum_{c \in C} \frac{1}{|C|} \sum_{d \in C} f((x \oplus c) \oplus d) \\
&= \frac{1}{|C|^2} \sum_{c,d \in C} f(x \oplus (c \oplus d)).
\end{aligned}$$

As C is linear, $c \oplus d$ runs over all elements of C exactly $|C|$ times for fixed c. Thus

$$(\mathcal{T}^2 f)(x) = \frac{1}{|C|^2} \cdot |C| \sum_{e \in C} f(x \oplus e) = \mathcal{T}f(x).$$

Hence $\mathcal{T}^2 = \mathcal{T}$. □

Additionally, $\mathcal{T}$ projects onto the subspace of C-invariant functions.

A.2 Error Correction Bound

Theorem 2. *A linear code $C \subset \mathbb{F}_2^n$ with minimum distance d corrects any error of Hamming weight t whenever $2t < d$.*

Proof. Let transmitted codeword $c \in C$ and received vector $r = c \oplus e$ with $\mathrm{wt}(e) = t$. For any distinct $c' \in C$,

$$\mathrm{dist}(r, c') = \mathrm{wt}(c' \oplus c \oplus e) \geq \mathrm{wt}(c' \oplus c) - \mathrm{wt}(e) \geq d - t,$$

while $\mathrm{dist}(r, c) = t$. If $t < d - t$ (i.e., $2t < d$), then c is the unique nearest codeword, so nearest-neighbour decoding recovers c. □

A.3 Existence of Stationary Distribution (Markov Chain)

The agent dynamics form a finite-state Markov chain on $\mathbb{F}_2^9$. Transformations are periodic applications of translations by codewords, interspersed with low-probability bit flips.

Theorem 3. *If the chain is irreducible and aperiodic, there exists a unique stationary distribution π, and convergence occurs from any initial state.*

Proof. Standard result for finite Markov chains: irreducibility ensures accessibility of all states; aperiodicity (guaranteed by random noise) ensures convergence to the unique stationary π (Perron–Frobenius theorem). □

In simulations, noise ensures these conditions, yielding the observed Gaussian marginals on Hamming weight planes.