Initial Conditions and Holographic Cosmology

Boltzmann's Brain vs. Cosmology and Evolution

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String Theory vs. Cosmology Workshop

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Holographic Cosmology and the Problem of Initial Conditions

Boltzmann-Penrose: Why Did the

Universe Begin in a Low Entropy State?

Boltzmann's Answer: Fluctuation in a

Finite System

Modern Version: Dyson Kleban Susskind

dS Space With Multi-Minimum Potential

Universe Began With Fluctuation

to High c.c. dS

Explains: Horizon, Homogeneity,

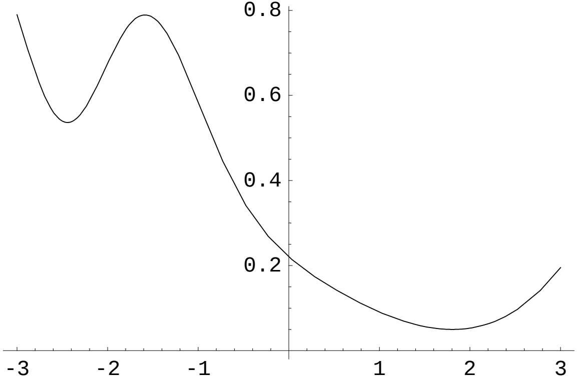
Low Entropy

I.C. *for* and Existential Necessity *of* Inflation

But Probability of Fluctuation Induced

Intelligence $\gg$ Prob. of Cosmology/Evolution:

Boltzmann's Brain


0.8
0.6
0.4
0.2
-3
-2
-1
1
2
3

$$e^{-2\pi m_I R} e^{-\pi(\frac{m_I}{M_P})^2} \text{ vs. } e^{-\pi(RM_P)^2}.$$

Problem For String Landscape As Well
Unless All dS Spaces w/ Life of Our Type

Decay to Negative c.c. Big Crunch
On Time Scale $\ll$ Thermal BB Probability.

But Doesn't Inflation Avoid

All of This? NO!!!

1. In Conventional Inflation DOF Start
Trans-Planckian. *Assume* in Ground State
And Apply Adiabatic Thm.

2. In Asy. Homogeneous Space: Infl. Patch Engulfed

In Small Entropy Black Hole

TBWIP: For Slow Roll, Sing. Eats Up Inflating Region

Inflation Postulates Solution of Horizon,
Homogeneity, Low Entropy Problems

Holographic Cosmology

Operator Algebra of Causal Diamond

Quantized Pixel = Superparticle

$$[S_a(m), S_b(n)]_+ = \delta_{ab}\delta_{mn}$$

Topological Space-time Lattice of Observers

$S_a(\mathbf{x}, t)$: Hilbert Space of 1 Observer
Fixed $\mathbf{x}$: Particle Horizon:
$H(t, \mathbf{x})$ Decouples $S_a(\mathbf{x}, s)$ $s > t, s < t$

$\mathcal{H}(\mathbf{x}, t)$ Contains $S_a(\mathbf{x}, s \leq t)$

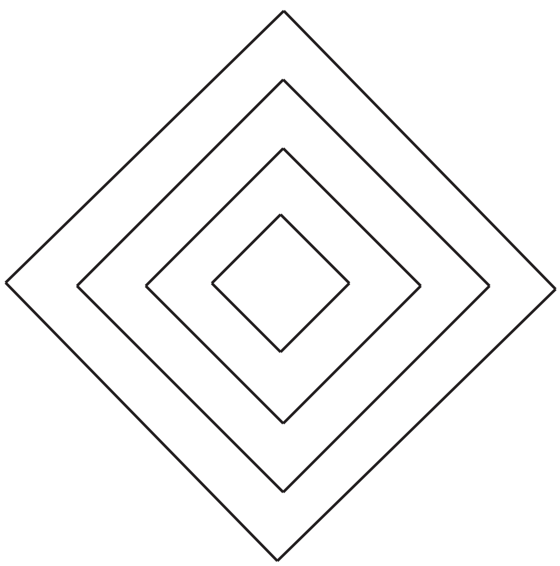
Consistency $\mathcal{H}(\mathbf{x}, t) = \mathcal{O}(\mathbf{x}, \mathbf{y}, t, s) \otimes \mathcal{N}(\mathbf{x}, \mathbf{y}, t, s)$

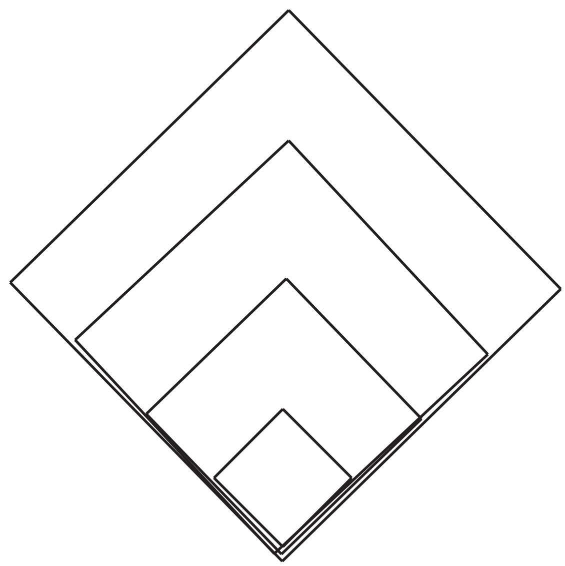
$$\mathcal{H}(\mathbf{y}, s) = \mathcal{O}(\mathbf{x}, \mathbf{y}, t, s) \otimes \mathcal{N}(\mathbf{y}, \mathbf{x}, s, t)$$

Dynamics Agrees on Overlap

One Known Solution: Fischler, Mannelli, TB
$\mathcal{O}(\mathbf{x}, \mathbf{y}t, t) = \mathcal{H}(\mathbf{x}, t - p) = \mathcal{H}(\mathbf{y}, t - p)$,

p Shortest Lattice Path from $\mathbf{x} \to \mathbf{y}$
Defines Causal Distance





Nested Causal Diamonds For Time Symmetric Space-Time

Nested Causal Diamonds For Big Bang Space-Time

Observer $H(t)$: Random Irrel. Pert.
Of Random Fermion Bilinear

This Model Has $t \to \infty$ Scaling Laws of

Flat $p = \rho$ FRW Cosmology

Eqn. of State: *Dense Black Hole Fluid*

Heuristic Picture of Real Cosmology

Maximal Entropy Defect in DBHF

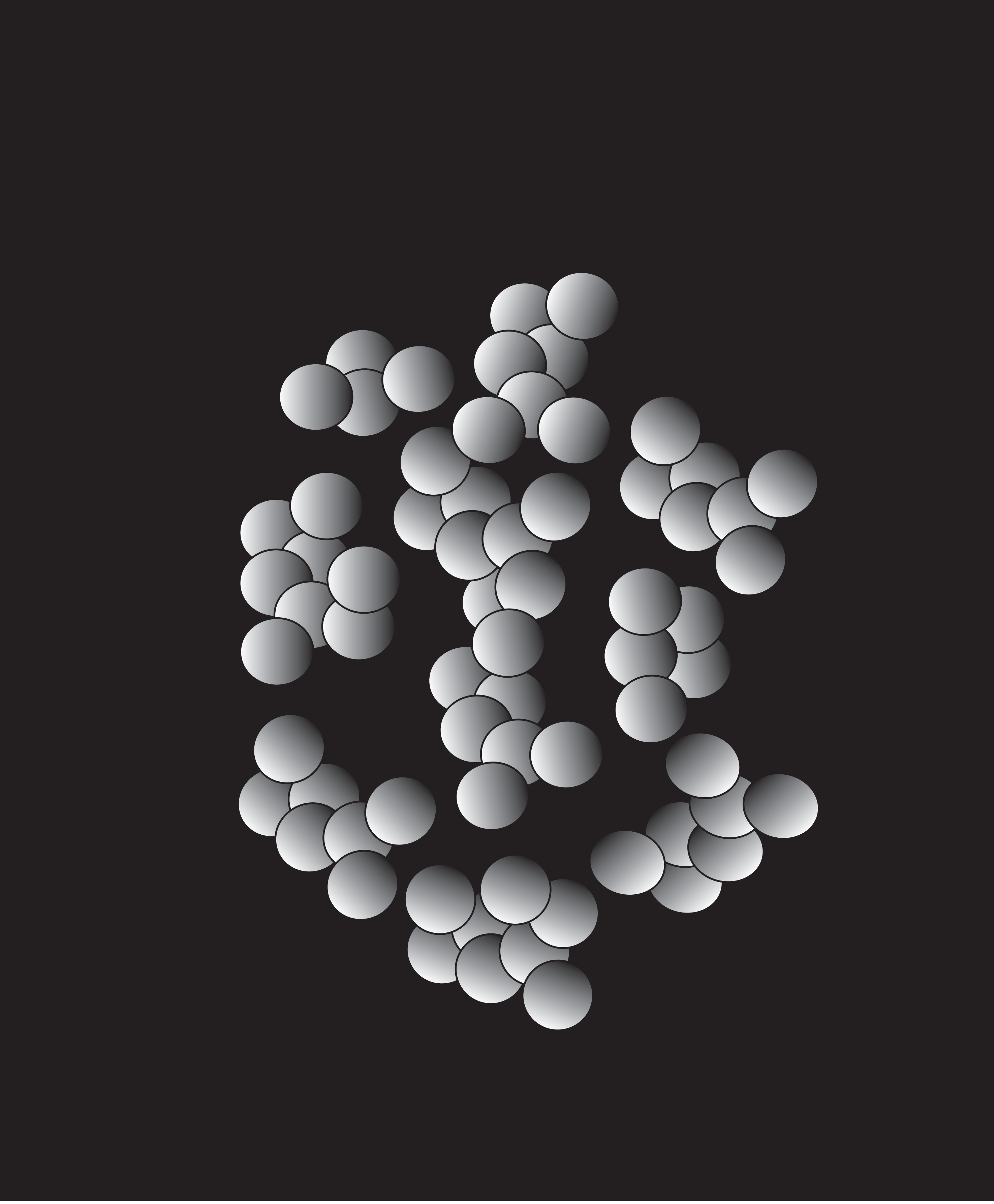


Fig 1. The initial "fractal" distribution of normal regions in the dense black hole fluid

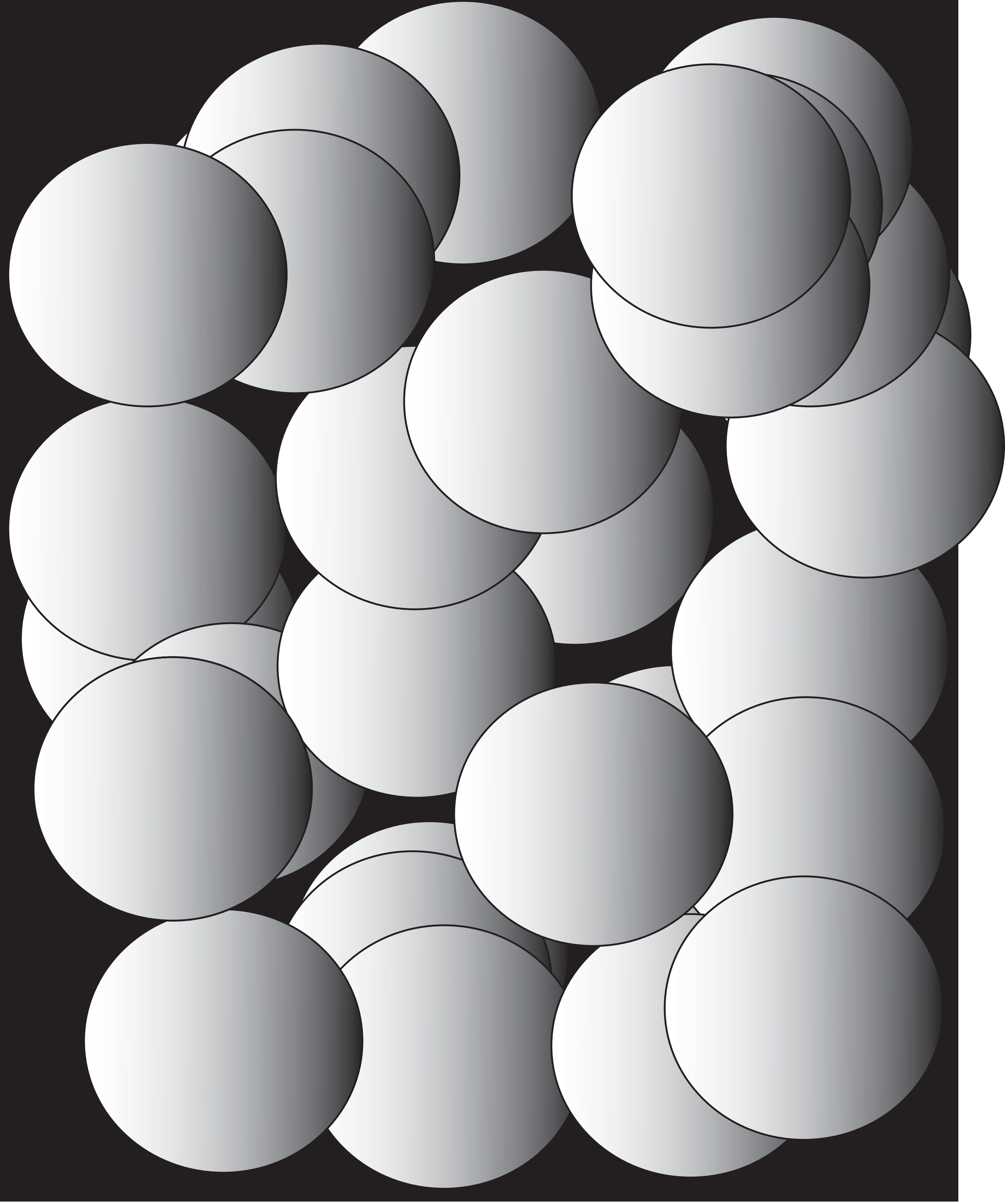


Fig 2. The normal regions begin to dominate the volume of the universe.

On Equal Area Time Slices

Normal Volume Grows Relative to DBHF

$\rightarrow$ Dilute BHG

Fluctuations Scale Invariant

Over Finite Range of Scales

1 To Horizon M at Transition

Fluctuations Must Be (How?) Small

Sets Up Almost Homogeneous I.C. For Inflation

Inflation Blows Up $p = \rho$ Fluctuations

Only Need ~ 10 e-Foldings To
Explain Correlations in CMB

Inflationary Fluctuations Too

$M \gg 1 \rightarrow$ Low Scale

Probably Means Super Natural Hybrid If Infl. Flucts.

No Gravity Waves

Could Be Single Field Slow Roll

If $p = \rho$ Flucts.

But $n_S = 1$ Ruled Out ??

Conclusions

Low Entropy I.C. a Puzzle

Inflation Doesn't Solve (Homogeneity)

DKS or Landscape Possible Explanation

But Boltzmann's Brain

Holographic Cosmology Gives Plausible

Incomplete Explanation of Homogeneity and

Low Entropy I.C.

Needs Only Small Amount of Inflation

Probably No Gravitational Waves