Title: The Lonely Multiverse of Holographic cosmology

Date: Sep 03, 2008 02:00 PM

URL: http://pirsa.org/08090046

Abstract:

# The Lonely Multiverse of Holographic Cosmology

T. Banks, Perimeter Institute

Conference on the Multiverse, September 2-4, 2008

# The Lonely Multiverse of Holographic Cosmology

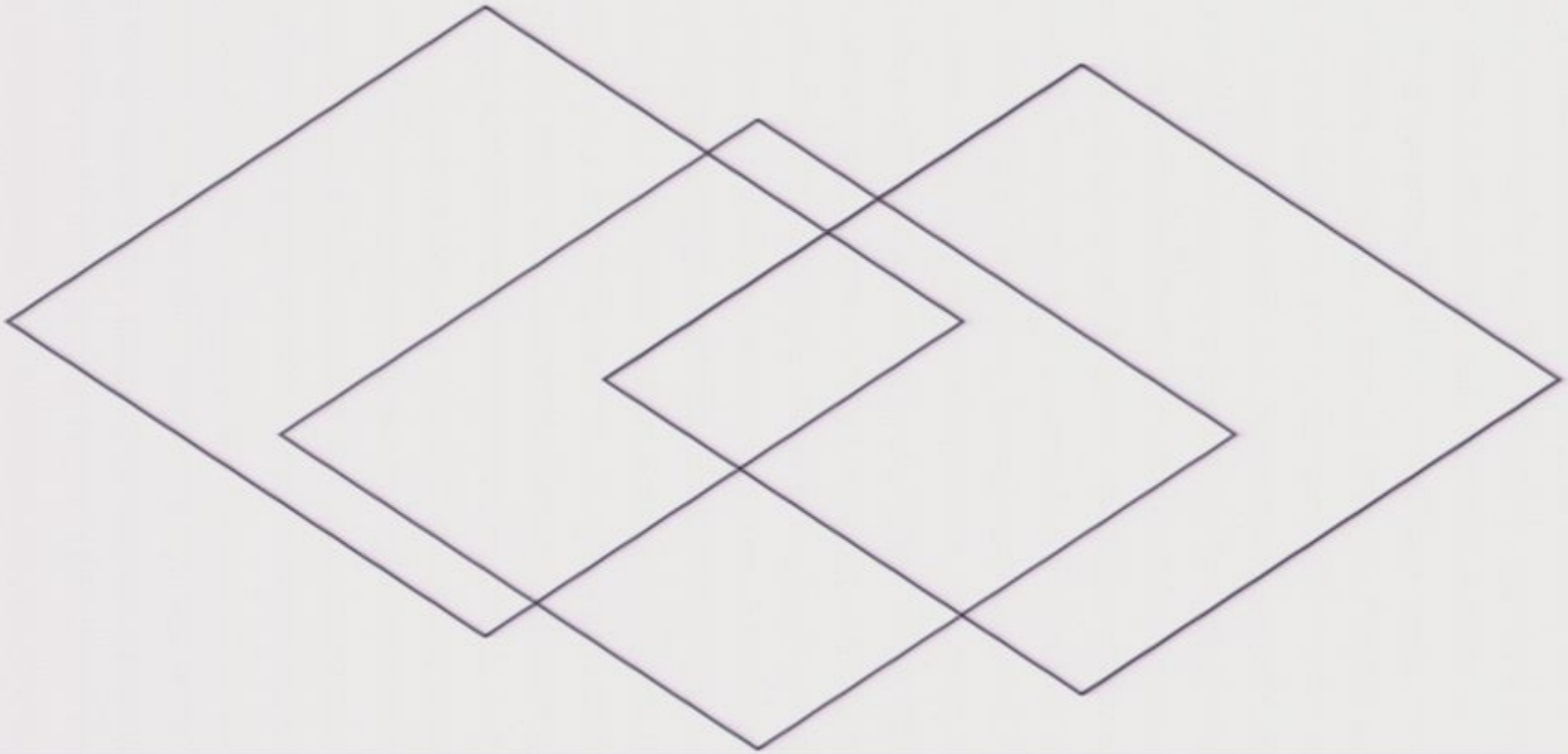
T. Banks, Perimeter Institute

Conference on the Multiverse,
September 2-4, 2008

# Holographic Space-Time

- Causal Diamond ← → Hilbert Space
- Maximal Diamond in Intersection: Tensor Factor $\Theta(n; \mathbf{x},\mathbf{y})$ in $\mathcal{H}(n, \mathbf{x} \text{ or } \mathbf{y})$
- **x** labels a topological spatial lattice
- Dim $\mathcal{H}(n, \mathbf{x}) = (\text{Dim } \mathcal{P})^n$
- $\mathcal{P}$ : Pixel Hilbert Space, Representation of $[S_a^I, S_b^J] = \delta_{ab} M^{IJ}$ $\{\chi^* \gamma^\mu \chi \gamma_\mu \chi = 0 \rightarrow = (0,S)\}$
- Pixel = Basis element of finite dimensional (non-abelian) function algebra on holoscreen

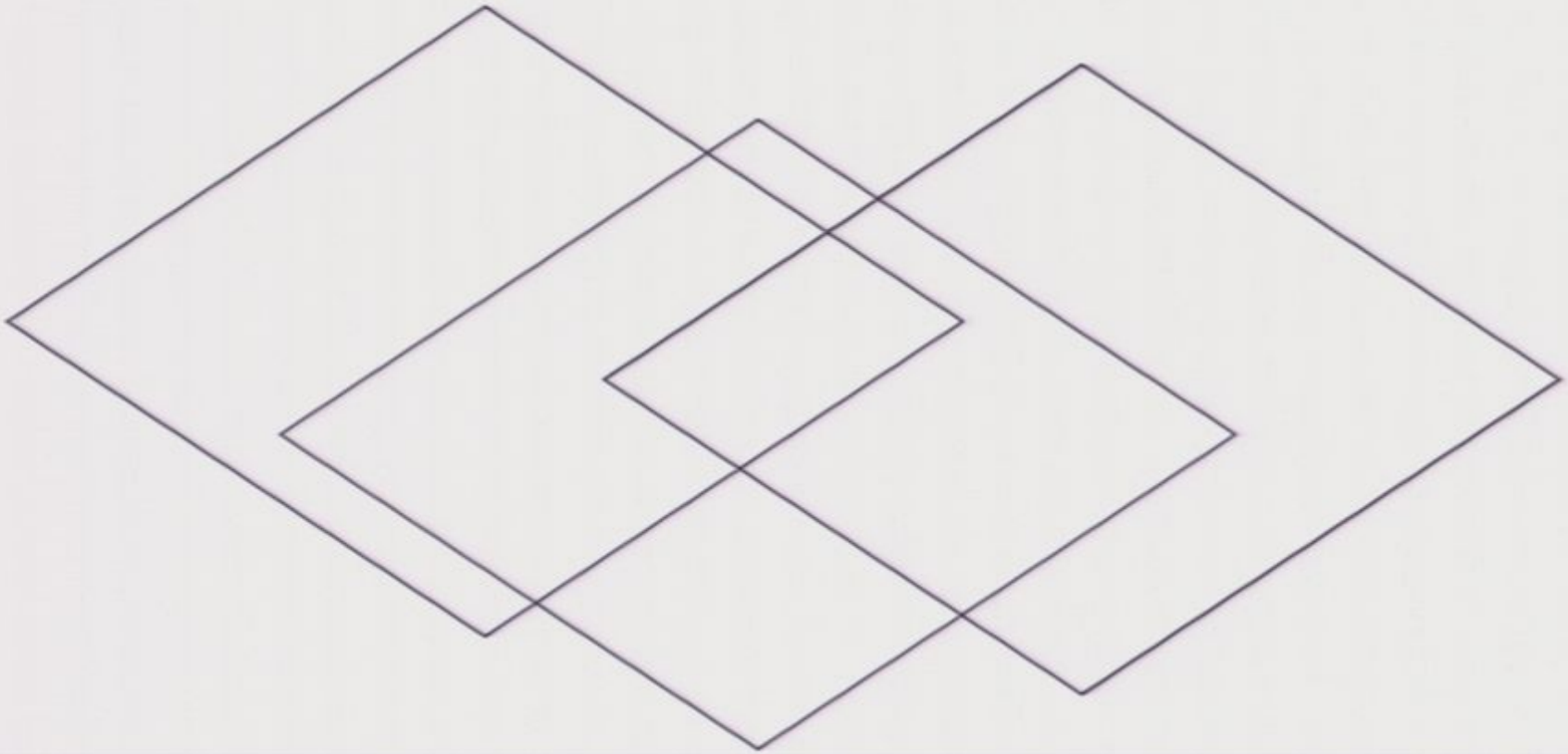
# Overlapping Causal Diamonds ← → Tensor Factorized Hilbert Spaces

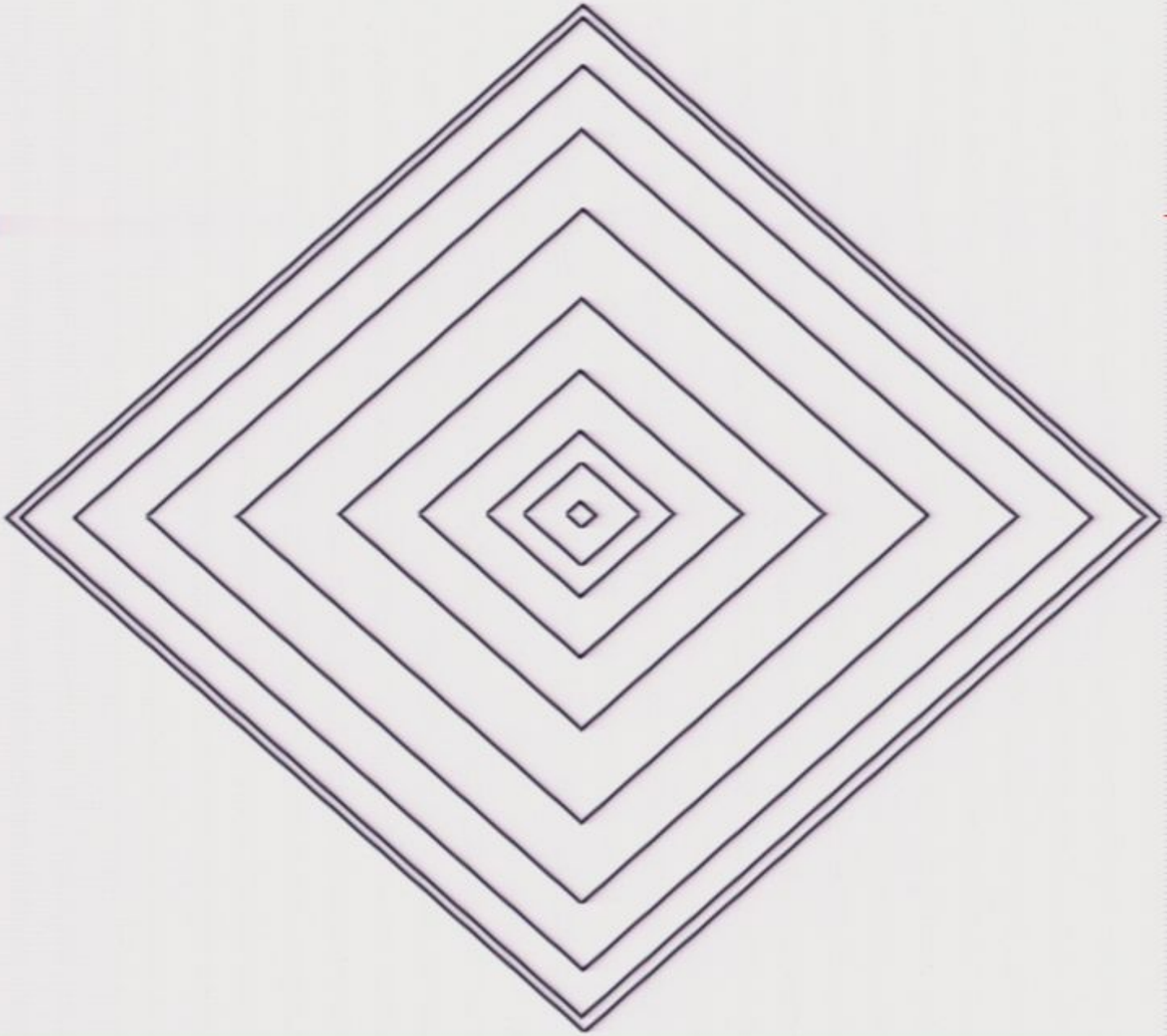


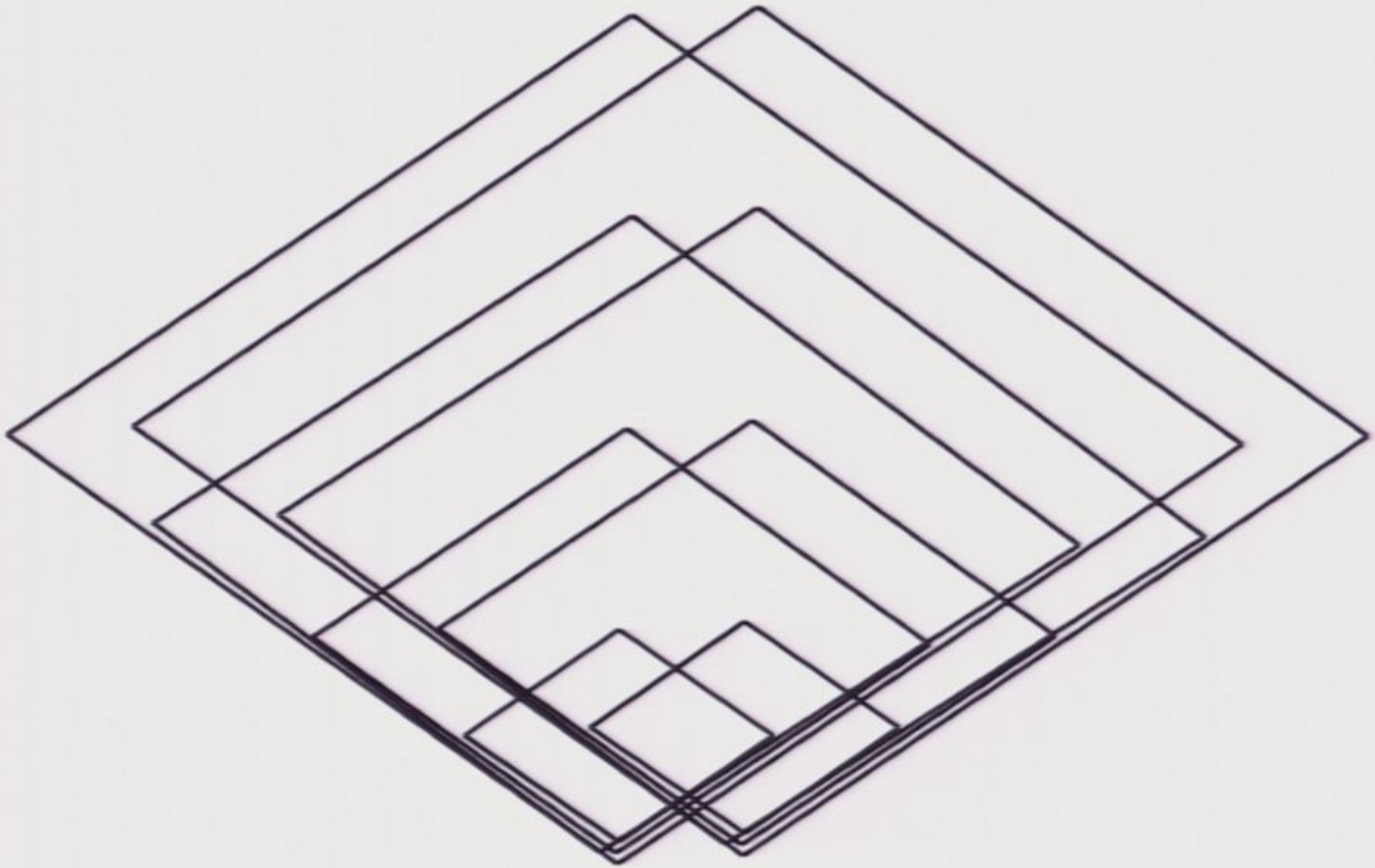
# Holographic Space-Time

- Causal Diamond ← → Hilbert Space
- Maximal Diamond in Intersection: Tensor Factor $\Theta(n; \mathbf{x},\mathbf{y})$ in $\mathcal{H}(n, \mathbf{x} \text{ or } \mathbf{y})$
- **x** labels a topological spatial lattice
- Dim $\mathcal{H}(n, \mathbf{x}) = (\text{Dim } \mathcal{P})^n$
- $\mathcal{P}$ : Pixel Hilbert Space, Representation of $[S_a^{\ I}, S_b^{\ J}] = \delta_{ab} M^{IJ}$ $\{\chi^* \gamma^\mu \chi \gamma_\mu \chi = 0 \rightarrow = (0,S)\}$
- Pixel = Basis element of finite dimensional (non-abelian) function algebra on holoscreen

# Overlapping Causal Diamonds ← → Tensor Factorized Hilbert Spaces



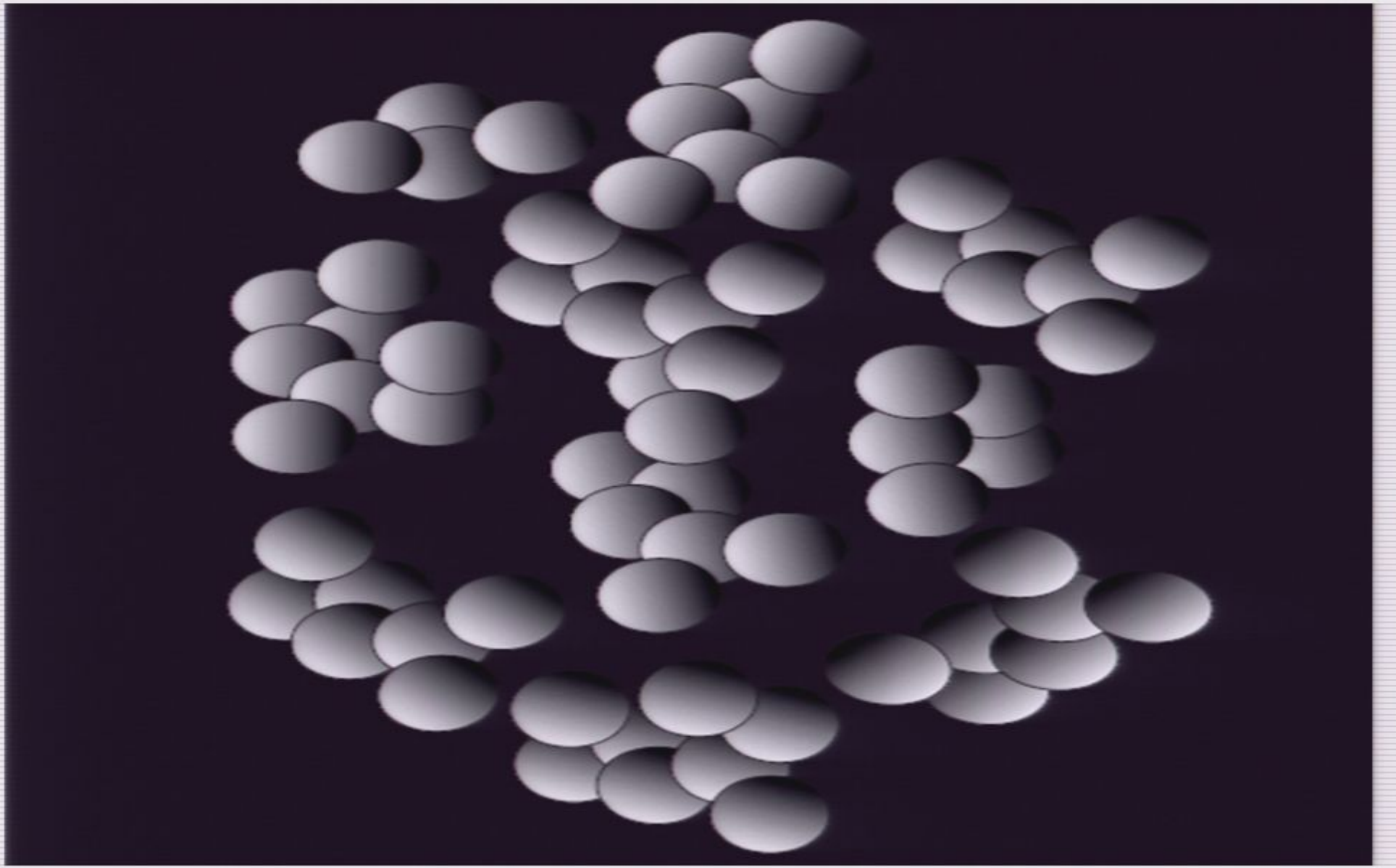




A Quantum Space-Time Is A
Spatial Lattice Of Overlapping
Nested Sequences of Causal Diamonds

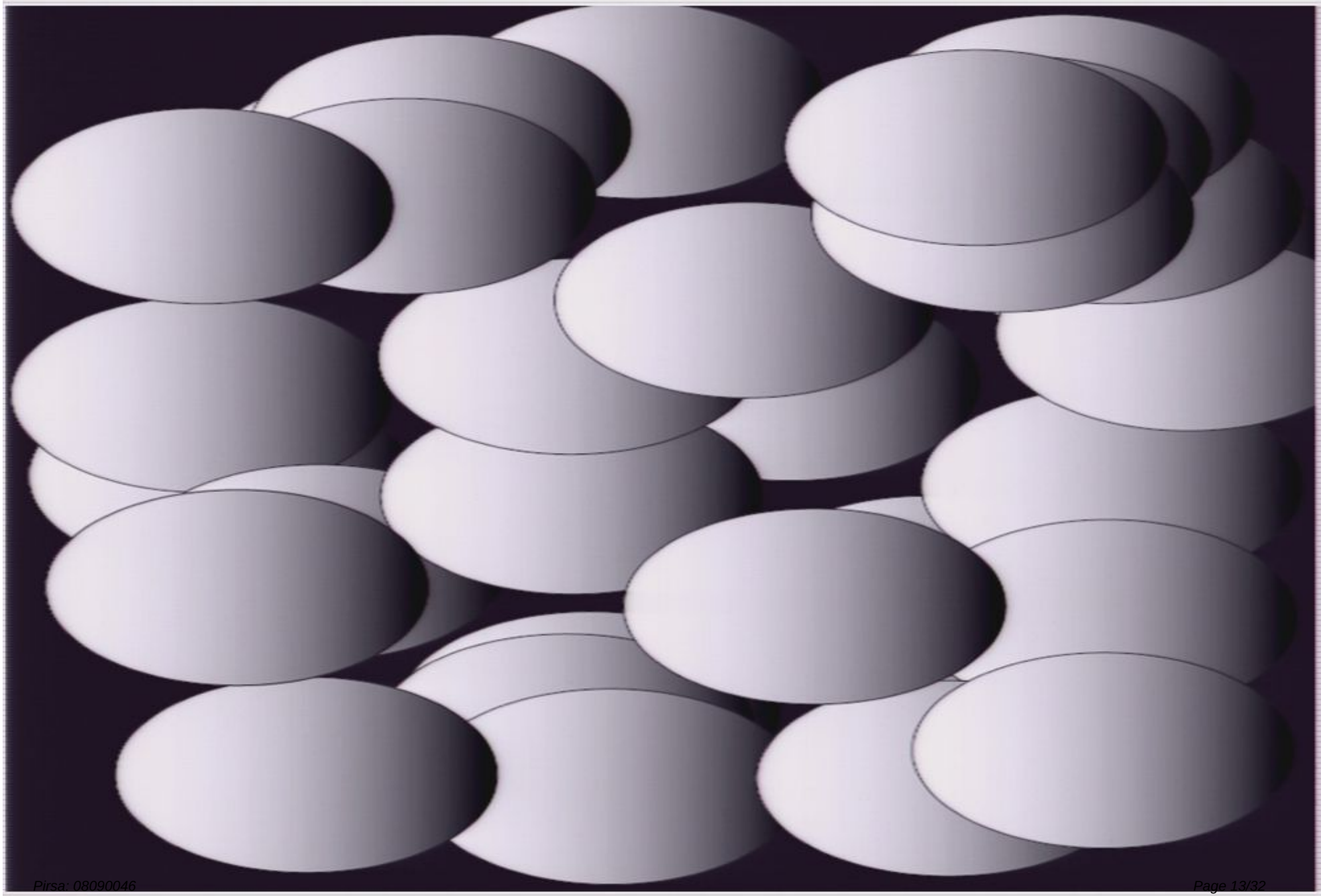
# Holographic Cosmology

- Dense Black Hole Fluid (DBHF): an explicit quantum model, which satisfies consistency conditions of holographic space time and gives rise to scaling laws of $p=\rho$ , flat FRW universe in the large area limit (TB, Fischler, Mannelli)
- TB, Fischler: Heuristic model of our universe as a low entropy defect in DBHF



# Properties of the DBHF Defect Model:

- Transition to dilute BH gas
- Sets up initial conditions for inflation
- Solves homogeneity, isotropy, flatness problems w/o inflation – only ~ 20 e-folds necessary to explain correlations in CMB
- Possible explanation for low entropy beginning but no quantitative calculation of initial fluctuation amplitude
- Another source of scale invariant fluctuations

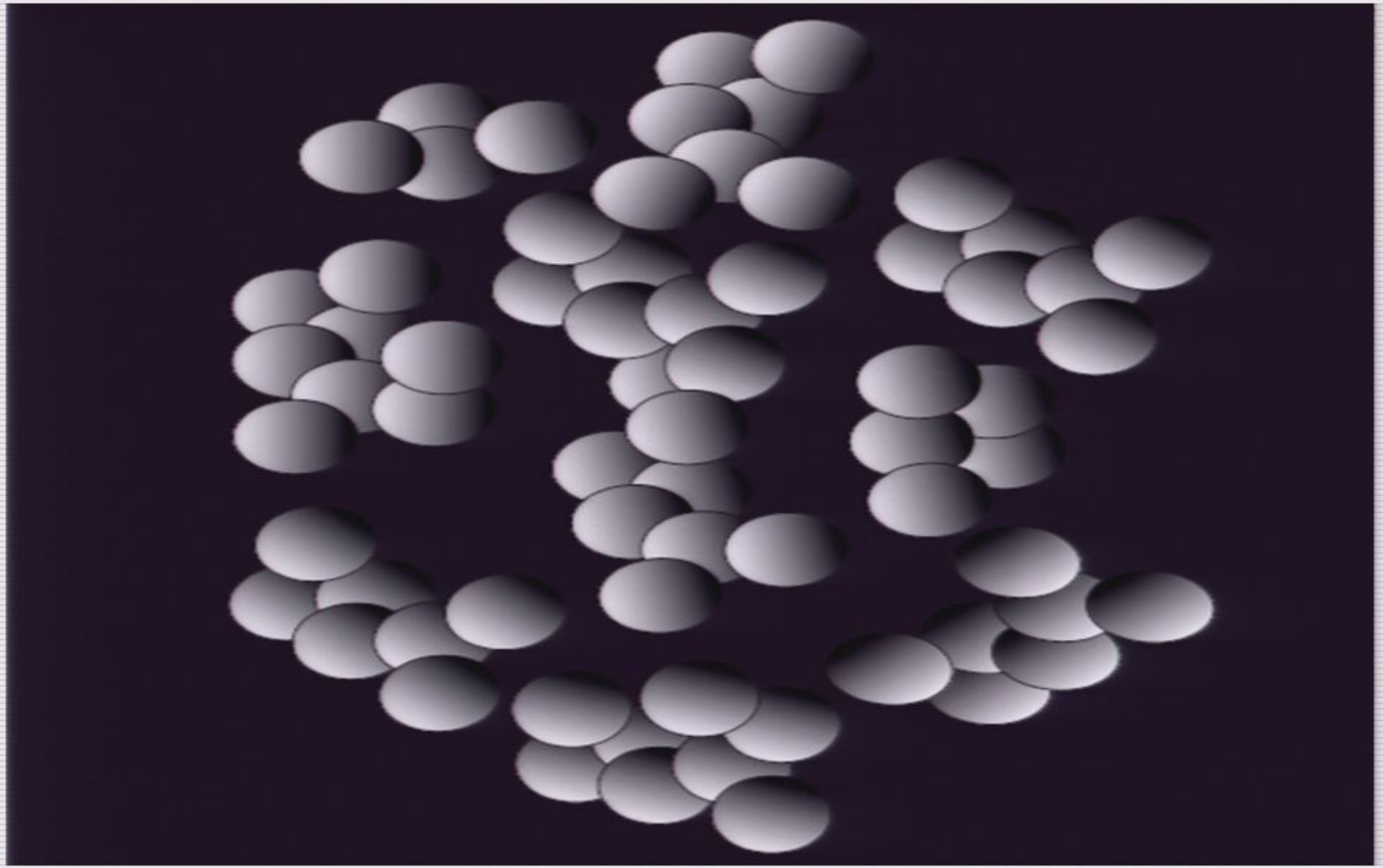


# Properties of the DBHF Defect Model:

- Transition to dilute BH gas
- Sets up initial conditions for inflation
- Solves homogeneity, isotropy, flatness problems w/o inflation – only ~ 20 e-folds necessary to explain correlations in CMB
- Possible explanation for low entropy beginning but no quantitative calculation of initial fluctuation amplitude
- Another source of scale invariant fluctuations

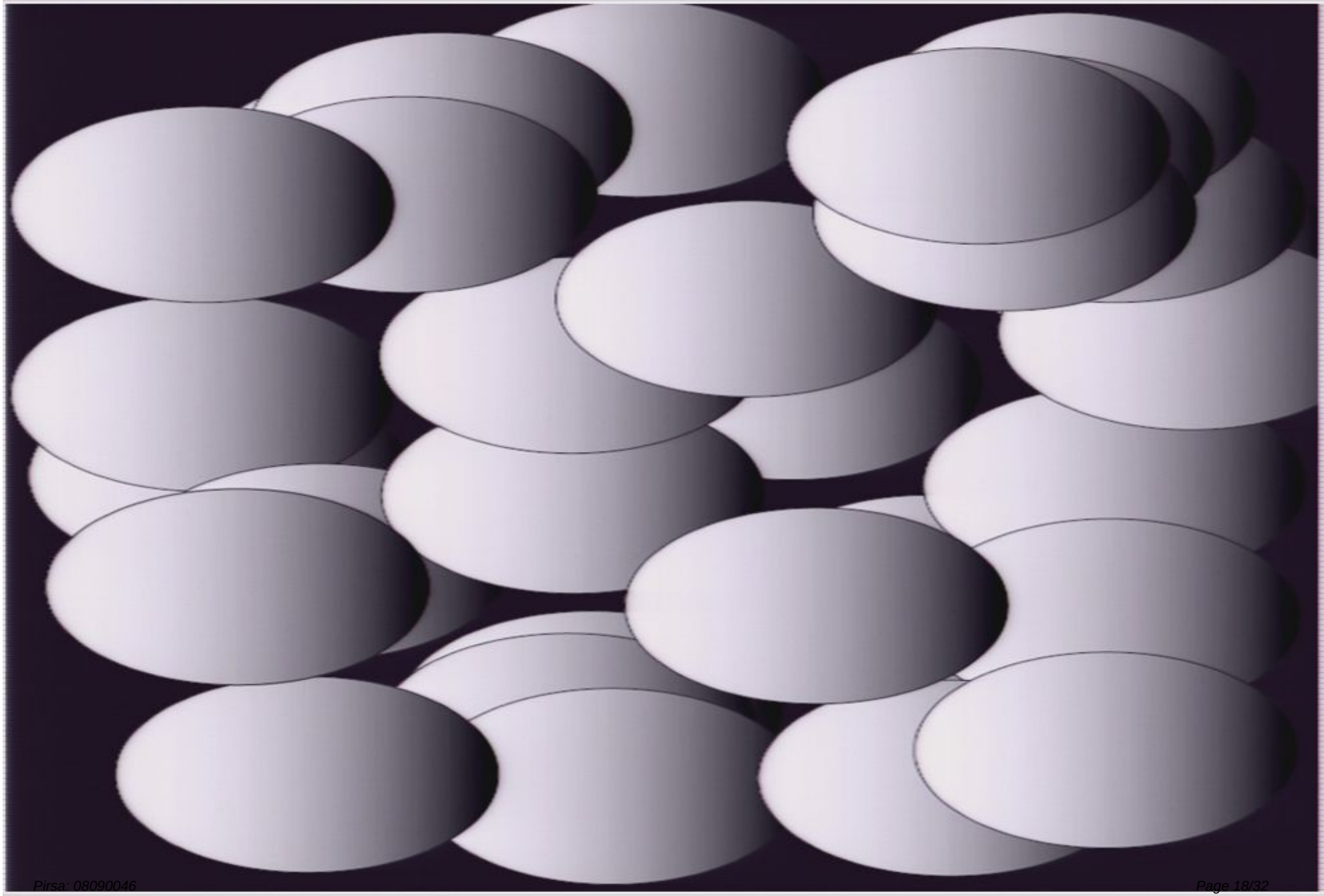
# Holographic Cosmology

- Dense Black Hole Fluid (DBHF): an explicit quantum model, which satisfies consistency conditions of holographic space time and gives rise to scaling laws of $p=\rho$ , flat FRW universe in the large area limit (TB, Fischler, Mannelli)
- TB, Fischler: Heuristic model of our universe as a low entropy defect in DBHF



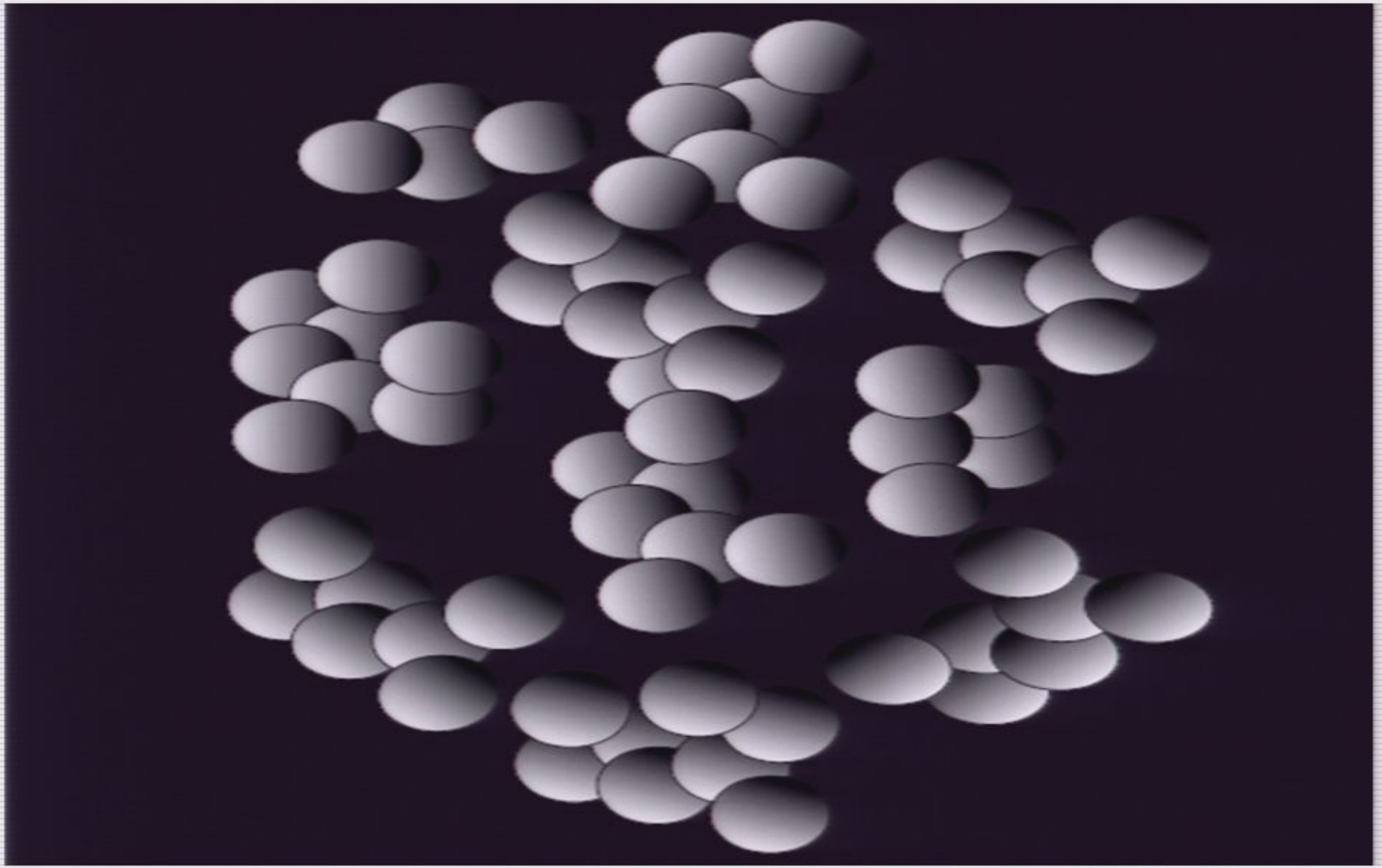
# Properties of the DBHF Defect Model:

- Transition to dilute BH gas
- Sets up initial conditions for inflation
- Solves homogeneity, isotropy, flatness problems w/o inflation – only ~ 20 e-folds necessary to explain correlations in CMB
- Possible explanation for low entropy beginning but no quantitative calculation of initial fluctuation amplitude
- Another source of scale invariant fluctuations



# Properties of the DBHF Defect Model:

- Transition to dilute BH gas
- Sets up initial conditions for inflation
- Solves homogeneity, isotropy, flatness problems w/o inflation – only ~ 20 e-folds necessary to explain correlations in CMB
- Possible explanation for low entropy beginning but no quantitative calculation of initial fluctuation amplitude
- Another source of scale invariant fluctuations



# Properties of the DBHF Defect Model:

- Transition to dilute BH gas
- Sets up initial conditions for inflation
- Solves homogeneity, isotropy, flatness problems w/o inflation – only ~ 20 e-folds necessary to explain correlations in CMB
- Possible explanation for low entropy beginning but no quantitative calculation of initial fluctuation amplitude
- Another source of scale invariant fluctuations

# For the present purpose:

- Most important property of DBHF defect model is that the universe MUST evolve to asymptotically de Sitter future.
- Asymptotic future c.c. determined by initial conditons (local number of states not in DBHF):
- A multiverse of lonely universes with range of possible c.c.'s : sprinkling of marginally trapped surfaces in $p=\rho$ background do not meet and join
- Other parameters of low energy physics may NOT be random, if theory of stable low c.c. dS relatively unique.

# More lessons from the holographic universe:

- Field theory is a good approximation only inside a large causal diamond in a normal universe
- Particles: isolated excited pixels on the screen of a "normal" causal diamond.
- Field theory is NOT a good approximation in the very early universe, even when $\rho << m_P^4$
- Only valid after transition to normal universe and in situations where it does not predict formation of event horizons with size > or = the particle horizon

# Rough criterion for validity of field theory

- Variables on holoscreen N X M matrices M ~ N
- When dynamics couples only $N^{3/2}$ block diagonal matrices, we get permutation statistics = particles
- More d.o.f. coupled = "Black Hole"

# Stable dS space

- C.C. in 4d Planck units determines total number of states. Division between internal excitations and particles in dS space depends on size of representation of single pixel algebra
- Limit of zero c.c. should be describable by SUGRA with fine tuned $W_0$. Asymptotic SUSic region of field space NOT allowed: dS would be meta-stable.
- Limit should have R symmetry and W = 0.
- No known examples → some evidence that such systems are rare or unique.

# Meta-stability

- For general potential, lowest dS minimum is unstable if either:
- There is a V = 0 region, possibly at infinity, or
- The $\Lambda$=0 limit is unstable
- Roughly ½ of potentials with no V = 0 points have stable dS. In particular, all those which become SUSic as $\Lambda \rightarrow 0$
- For these, CDL transitions to V < 0 region have probability $\sim e^{-\text{Entropy}}$ , and are interpreted as temporary sojourns in low entropy state.

# Conclusions

- Holographic cosmology gives a plausible account of the beginning of the universe, including a possible explanation of initial conditions.
- Sets up conditions for inflation, but needs much less inflation to explain cosmological puzzles (only scale and possibly structure of CMB fluctuations).
- Predicts asymptotic dS universe with c.c. determined by initial conditions – the lonely multiverse
- Other parameters of low energy physics may be highly constrained by as yet incomplete theory of stable dS space.
- Many field theoretic prejudices are not true in this framework

# More lessons from the holographic universe:

- Field theory is a good approximation only inside a large causal diamond in a normal universe
- Particles: isolated excited pixels on the screen of a "normal" causal diamond.
- Field theory is NOT a good approximation in the very early universe, even when $\rho << m_P^4$
- Only valid after transition to normal universe and in situations where it does not predict formation of event horizons with size > or = the particle horizon

# For the present purpose:

- Most important property of DBHF defect model is that the universe MUST evolve to asymptotically de Sitter future.
- Asymptotic future c.c. determined by initial conditons (local number of states not in DBHF):
- A multiverse of lonely universes with range of possible c.c.'s : sprinkling of marginally trapped surfaces in $p=\rho$ background do not meet and join
- Other parameters of low energy physics may NOT be random, if theory of stable low c.c. dS relatively unique.

# More lessons from the holographic universe:

- Field theory is a good approximation only inside a large causal diamond in a normal universe
- Particles: isolated excited pixels on the screen of a "normal" causal diamond.
- Field theory is NOT a good approximation in the very early universe, even when $\rho << m_P^4$
- Only valid after transition to normal universe and in situations where it does not predict formation of event horizons with size > or = the particle horizon

# Rough criterion for validity of field theory

- Variables on holoscreen N X M matrices M ~ N
- When dynamics couples only $N^{3/2}$ block diagonal matrices, we get permutation statistics = particles
- More d.o.f. coupled = "Black Hole"

# Conclusions

- Holographic cosmology gives a plausible account of the beginning of the universe, including a possible explanation of initial conditions.
- Sets up conditions for inflation, but needs much less inflation to explain cosmological puzzles (only scale and possibly structure of CMB fluctuations).
- Predicts asymptotic dS universe with c.c. determined by initial conditions – the lonely multiverse
- Other parameters of low energy physics may be highly constrained by as yet incomplete theory of stable dS space.
- Many field theoretic prejudices are not true in this framework