The thermodynamics of the equation of state: \( p = \rho \)

\[
dE = TdS - pdV
\]

locally:

\[
\sigma \sim \rho^{1/2}
\]

This is the statistical mechanics of a 1+1 dim. CFT (not a homogeneous scalar field)

Mechanical picture of \( p = \rho \)

Dense gas of black holes

\[
\sigma \sim \frac{R^{D-2}}{R^{D-1}} \sim R^{-1}
\]

\[
\rho \sim \frac{R^{D-3}}{R^{D-1}} \sim R^{-2}
\]

\[
\sigma \sim \rho^{1/2}
\]
The storage of information requires space. The merger of black holes leads to bigger black holes. Most entropic and robust initial state.

The dense gas of black holes has a conformal Killing symmetry:

$$p = \rho$$

Unlike other fluids, this fluid has no observable changes in scale that can detect.

The dynamics of this fluid is

$$ds^2 = dt^2 - \frac{c^2}{t^2} dx_i dx^i$$

$$t \rightarrow \lambda t$$

$$x_i \rightarrow \lambda^{2/3} x_i$$

conformally invariant.
Continuity of the geometry:

\[ tR^2(t) = t^{2/3}L^2 \]

\[ R(t) \sim t^{-1/6} \]

“normal” region shrinks

Synchronize times:

equal area slicing

Most entropic initial state consistent with survivability

\[ p = \rho \]

“Normal Regions”

\[ \frac{V_{\kappa=1/3}}{V_{\kappa=1}} = \epsilon \]
"Normal region" domination

Interstitial black hole:

\[ m_{BH} = M \]

\[ \frac{V_{\kappa=1/3}}{V_{\kappa=1}} = \epsilon t^{1/2} \]

\[ t_{\text{transition}} \sim \frac{1}{\epsilon^2} \]

The fluctuations in the "fractal" must be small in order for the universe to avoid recollapse to the

\[ p = \rho \quad \text{fluid} \]

The horizon and flatness problems are solved:

"A homogeneous and flat

\[ p = \rho \quad \text{universe saturates the entropy bound}"
Fluctuations, $\delta \rho_F$, in the “fractal” get transferred to fluctuations, $\delta \rho_{BH}$, in the positions and sizes of the interstitial black holes.

Assuming the probability distribution for $\delta \rho_F$ is invariant under the conformal symmetry:

$$< \delta \rho_{BH}(k,T) \delta \rho_{BH}(-k,T) > \sim \frac{1}{k^3}$$

Scale invariant spectrum

The physical size of the horizon, during the $p = 0$ black hole era, grows like $Ma^{3/2}$.

The energy density drops like $\frac{1}{M^2 a^3}$.

The “normal regions” has all the low energy degrees of freedom, moduli...

$$\mathcal{L} = \frac{1}{2} G_{ij}(\phi) \nabla \phi^i \nabla \phi^j - \mu^4 V(\phi)$$

When $Ma^{3/2} \geq \mu^{-2}$ it is possible to enter a period of slow roll inflation followed by reheating to:

$$T_R \sim \mu^3$$
The parameters of the model: $M$, $a$, $\mu$ and $N_e$

1) \[ M^{2/3} \geq 10^4(6) \] scale invariance should extend over three (five) decades

2) \[ \mu^4 = \frac{1}{M^2 \alpha^3} \] Inflation starts at the end of the black hole dominated era

3) \[ 10^{29} M^{-1/3} \mu^{7/3} \leq e^{N_e} \leq 10^{25(23)} M^{1/3} \mu^{7/3} \]

\[ R_{\text{corr}} \geq R_{\text{now}} \quad 10 M^{-2/3} R_{\text{corr}} \leq 10^{-3(5)} R_{\text{now}} \]

Scale invariance ranging from the present horizon down to $100(1) \times$ galactic scale
Parameters of the cosmological model

\[ T_R \sim \mu^3 \quad M^2 a^3 = \frac{1}{\mu^4} \]

\[
\begin{array}{|c|c|c|c|}
\hline
\mu & T_R & M & N_e \\
\hline
10^{-22/3} & 1 MeV & 10^{13} & 17 \leq N_e \leq 31 \\
10^{-15/4} & 10^{5(0)} TeV & 10^{6(9)} & 41(39) \\
10^{-21/4} & & & \\
\hline
\end{array}
\]

\[ M^{2/3} \geq 10^{4(6)} \]

scale invariance over at least 3(5) decades

Relative probability of the initial conditions for our model versus models of inflation

Take an equal area slice where the area of the horizon is \( A \)

The entropy of the initial conditions that lead to the "fractal" \( \sim A \)

For inflation, the entropy of the initial conditions \( \leq A^{3/4} \)
\[
< \delta \rho_{BH}(k, T) \delta \rho_{BH}(-k, T) \sim \int_{1}^{T} dsds' < \rho_{F}(k, s) \rho_{F}(-k, s') > = \int_{1}^{T} dsds' G(k, s, s')
\]

\[
\delta \rho_{BH}(x, T) = \int_{1}^{T} ds \int d^{3}yf(T, s, x - y) \rho_{F}(s, y)
\]

where \( \int d^{3}x \rho_{F} \) is invariant.

f falls off at large separation in a time independent way

\[
G(\lambda^{-2/3}k, \lambda s, \lambda s') = G(k, s, s')
\]

\[
< \delta \rho_{BH}(k, T) \delta \rho_{BH}(-k, T) > \sim \frac{1}{k^{3}} \int_{k^{3/2}}^{k^{3/2}T} dsds' G(1, s, s')
\]