some References relevant to CCC

R.P. (2006) Before the big bang: an outrageous new perspective and its implications for particle physics. In *EPAC 2006 – Proceedings, Edinburgh Scotland*, pp. 2759–62 ed. C.R. Prior (Edinburgh Physical Society Accelerator Group EPS-AG).

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Meissner, K.A., Nurowski, P. & Ruszczycki, B. (2013) Structures in the microwave background radiation. *Proc. R. Soc. A* 469: 2155, 20130116.

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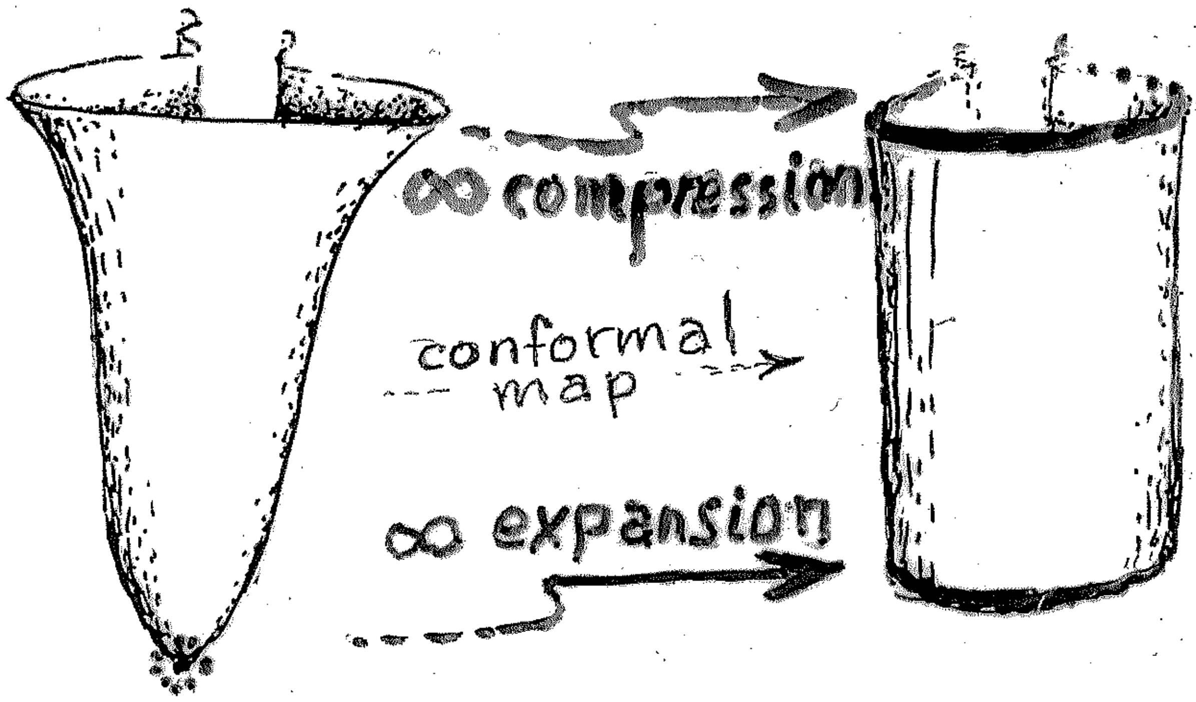
Two Mathematical Tricks

1. Squash down future infinity to get smooth future boundary

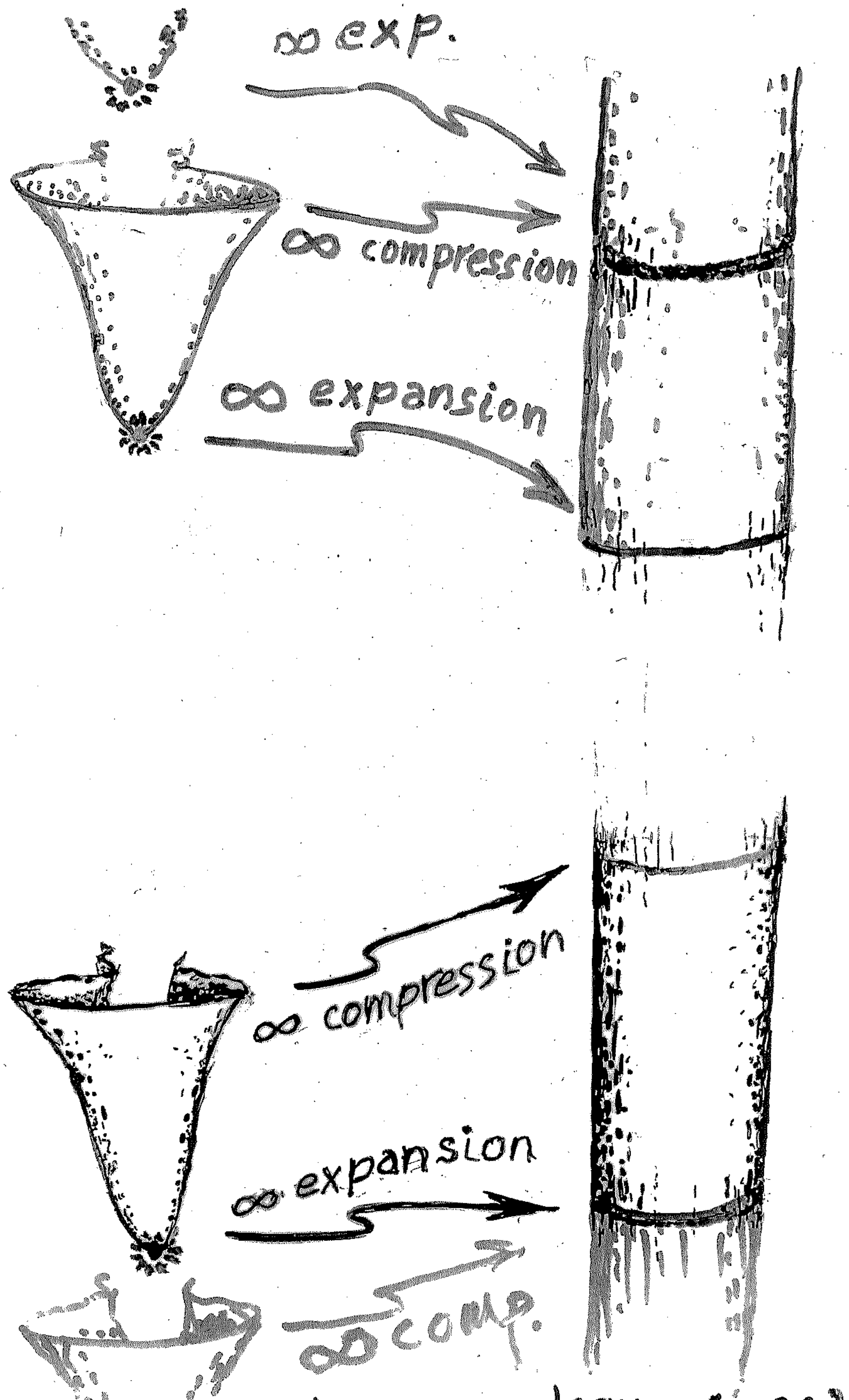
2. Stretch out Big Bang singularity to get smooth initial boundary



∞ compression
conformal map
∞ expansion

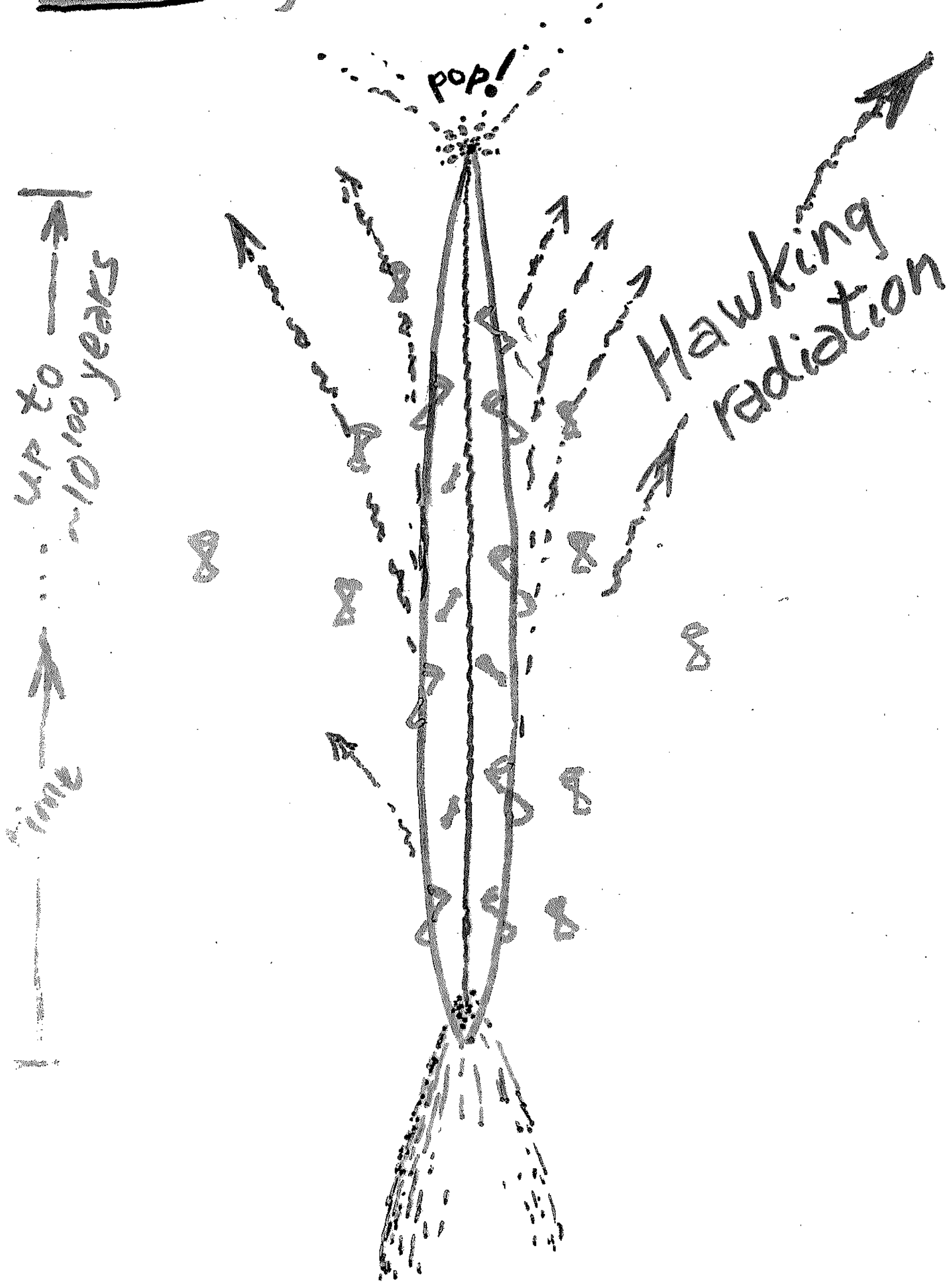
- Works under very general circumstances (H. Friedrich)
  (positive Λ)

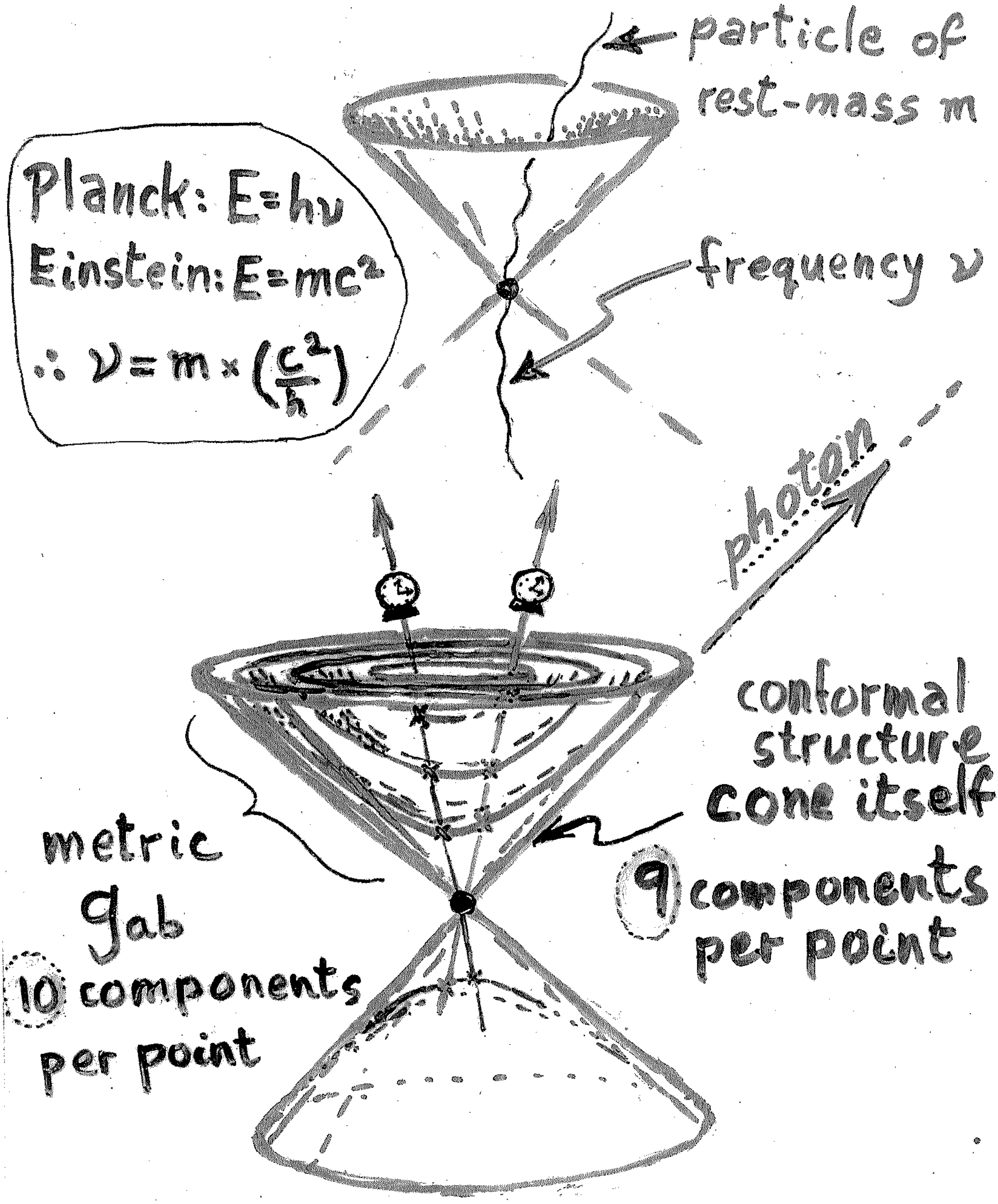
- Extremely strong restriction suppressing gravitational degrees of freedom (K.P. Tod)



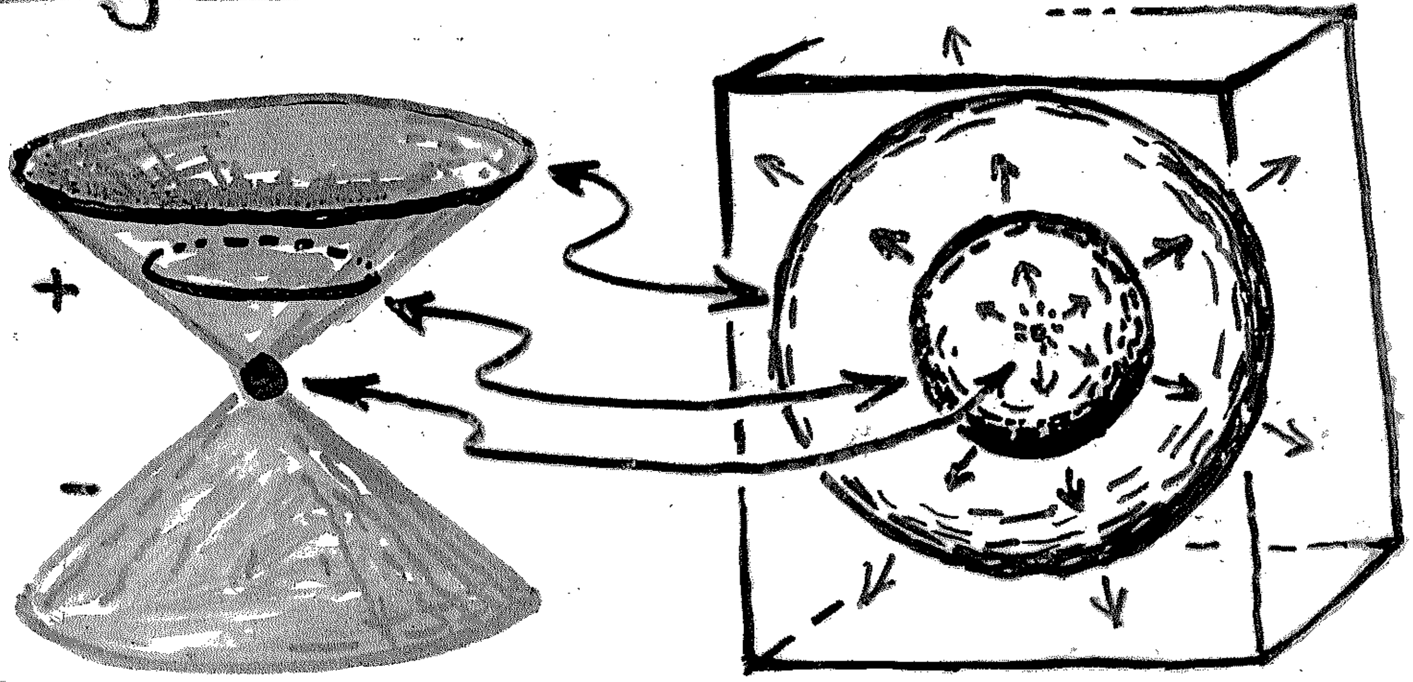
Conformal cyclic cosmology (ccc)

Hawking evaporating black hole



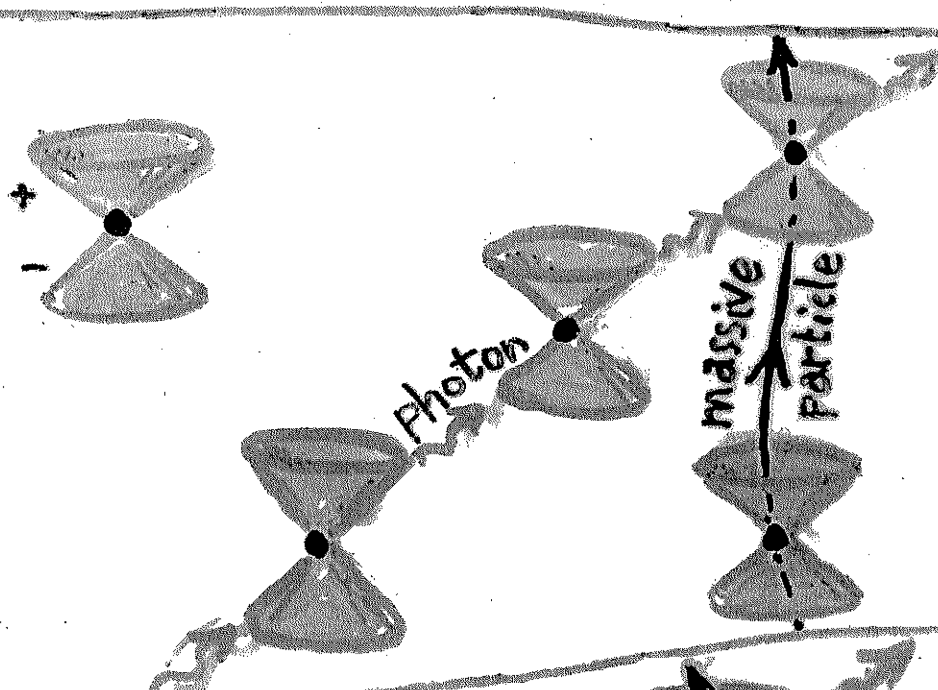

particle of
rest-mass m
Planck: E=hν
Einstein: E=mc²
∴ ν=m×(c²/h)
frequency ν
photon
conformal
structure
cone itself
9 components
per point
metric
gab
10 components
per point

Light cones

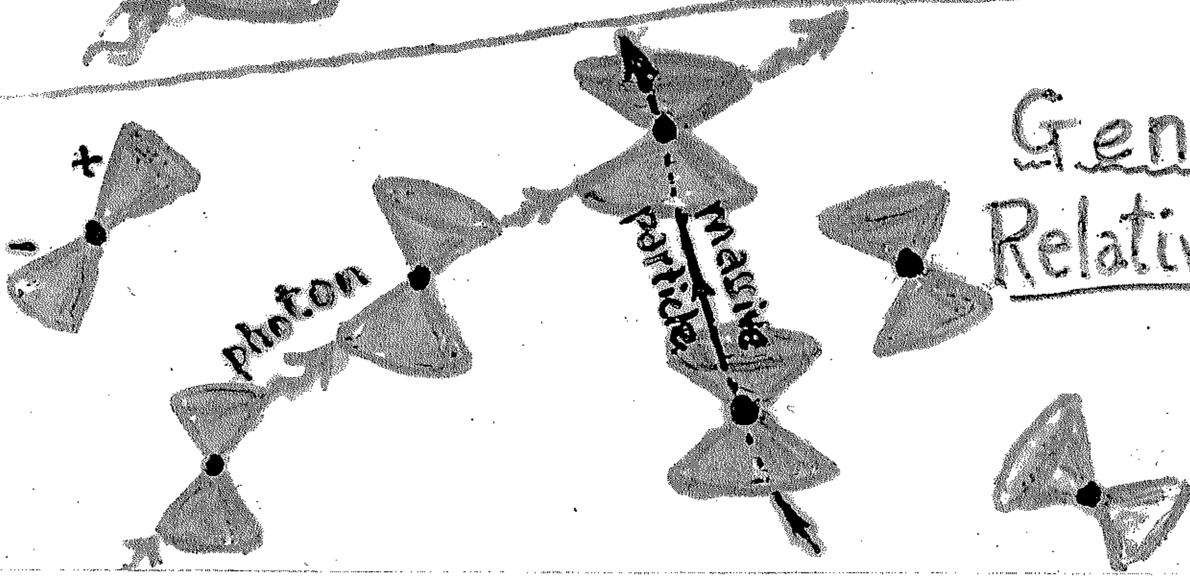


Space-time picture

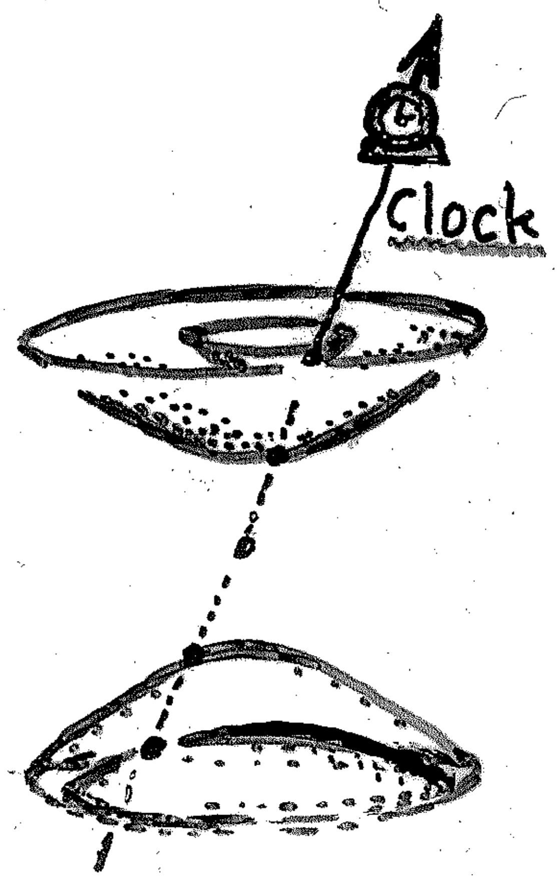
Space picture



Special Relativity



General Relativity



24+22

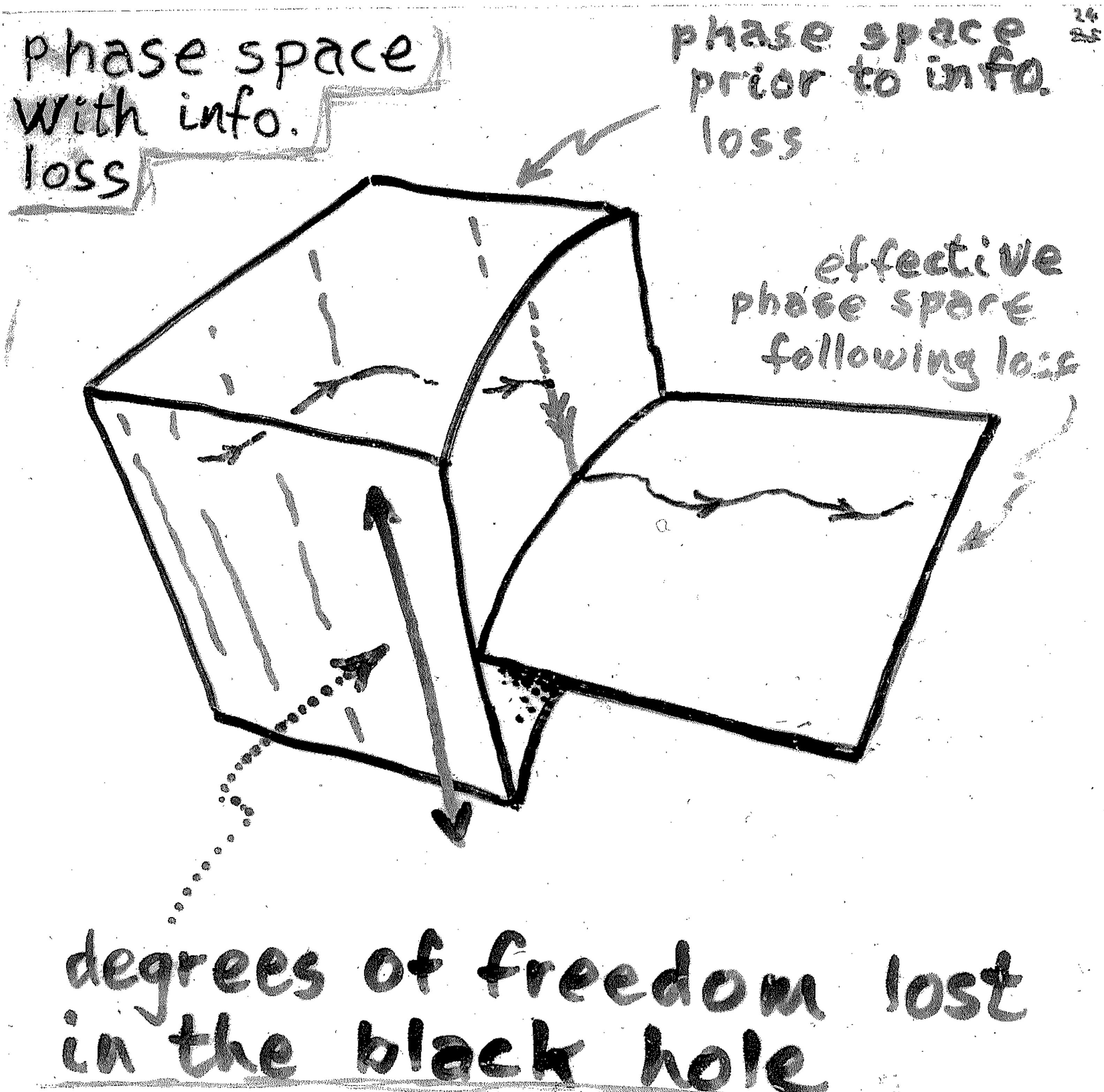
(22)

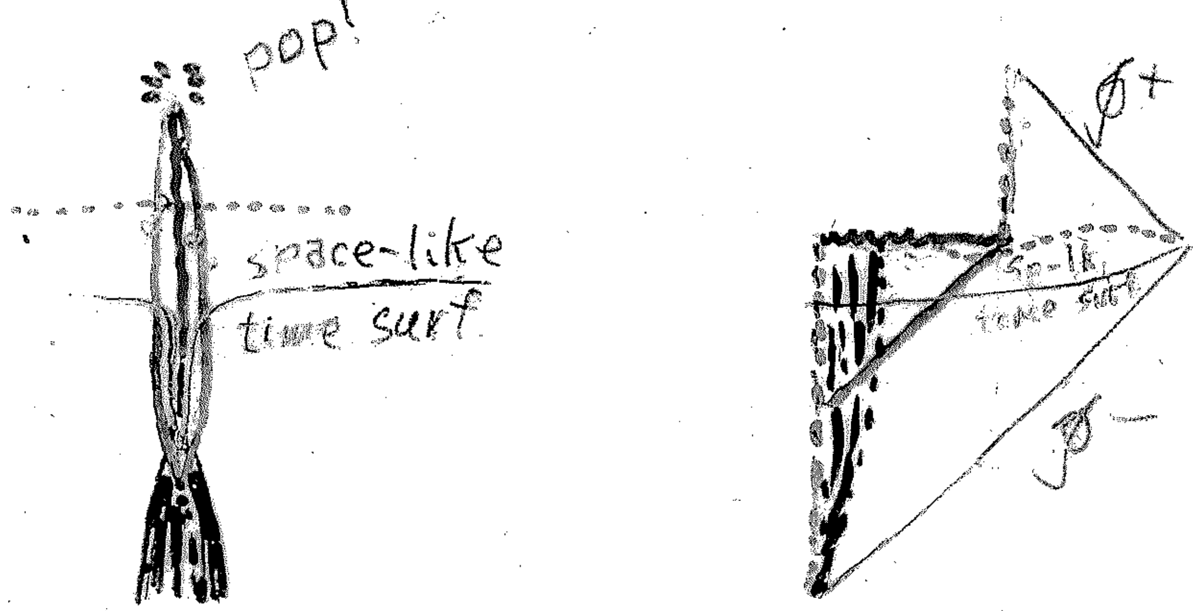
The second law of thermodynamics: how can this make sense in a cyclic universe?

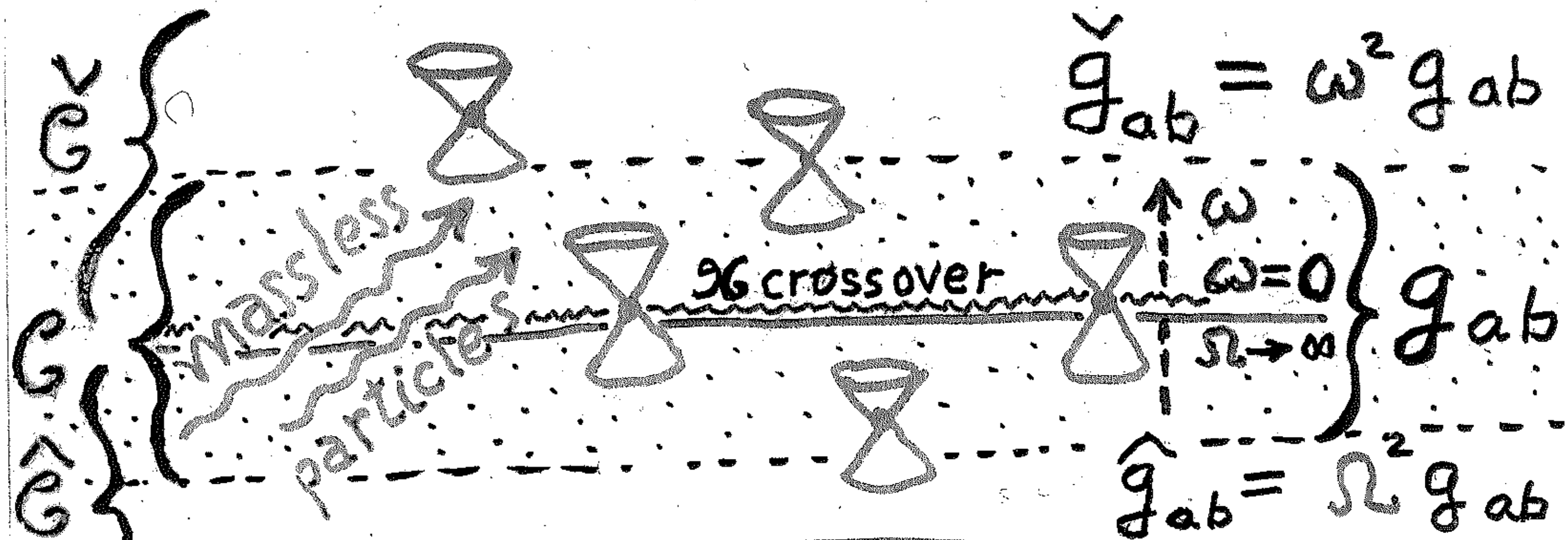
Degrees of freedom (i.e. "information") get LOST at black holes' singularities
Agrees with the young (1976) Hawking; disagrees with the old (2004) Hawking!

By FAR the greatest entropy around today is in huge super-massive black hole.

As these black holes eventually evaporate away, their lost degrees of freedom no longer contribute to the total entropy value
The ZERO of entropy is then re-set
The 2nd Law is "transcended", not violated


phase space with info. loss
phase space prior to info loss
effective phase space following loss
degrees of freedom lost in the black hole


pop!
space-like
time surf



Reciprocal hypothesis: $\Omega = -\frac{1}{\omega}$

$$\Pi = \frac{d\omega}{1-\omega^2} = \frac{d\Omega}{\Omega^2 - 1}$$ smooth across $\mathscr{X}$

Cosmological units: $c = 1,\ h = 2\pi,\ \Lambda = 3$

Note: necessarily $\Lambda > 0$; allows G to vary

$\Lambda = 3$ implies $\Pi_a \Pi^a = 1$ on $\mathscr{X}$

Delayed rest-mass hypothesis:

$$\Pi_a \Pi^a = 1 + \omega^2 + O(\omega^3)$$

Gives effectively unique propagation across $\mathscr{X}$ where we assume only massless fields in $\hat{\mathcal{G}}$ and $\mathcal{G}$, so traceless energy tensors

$$\hat{T}_a{}^a = 0 \quad (T_a{}^a = 0) \text{ whence } \check{S}_a{}^a = \frac{3(\Omega^2-1)^2}{2\pi G}(\Pi_a \Pi^a - 1)$$

Q

where Q is some universal constant

Weyl conformal tensor
(conformal 4-curvature)

$$C_{ab}{}^{cd} = R_{ab}{}^{cd} - 2R_{[a}{}^{[c}g_{b]}{}^{d]} + \tfrac{1}{3}R\, g_{[a}{}^{c}g_{b]}{}^{d}$$

Under conformal rescaling $\hat{g}_{ab} = \Omega^2 g_{ab}$

we have $\hat{C}_{abcd} = \Omega^2 C_{abcd}$

"graviton field" tensor K_{abcd}

$(K_{abcd} = K_{[cd][ab]},\ K_{[abc]d} = 0,\ K^a{}_{abc} = 0)$

satisfies $\hat{K}_{abcd} = \hat{C}_{abcd}$ and has

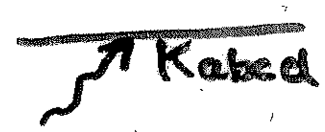
conformally invariant wave eqn.

$\nabla^a K_{abcd} = 0$, i.e. $\nabla_{[a} K_{bc]de} = 0$

Conf. invariance from: $\hat{K}_{abcd} = \Omega K_{abcd}$

We find that K_{abcd} is finite at $\mathscr{I}$

whence $C_{abcd} = 0$ at $\mathscr{I}$



Phantom field eqn: $(\Box + 2)\Omega = 2\Omega^3$

Getting Ω from Π: $2\check{\Omega} = \dfrac{\nabla^a \Pi_a}{1 - \Pi_a \Pi^a}$ $\quad \nabla^a \Pi_a = 2Q(\omega) + O(\omega^2)$

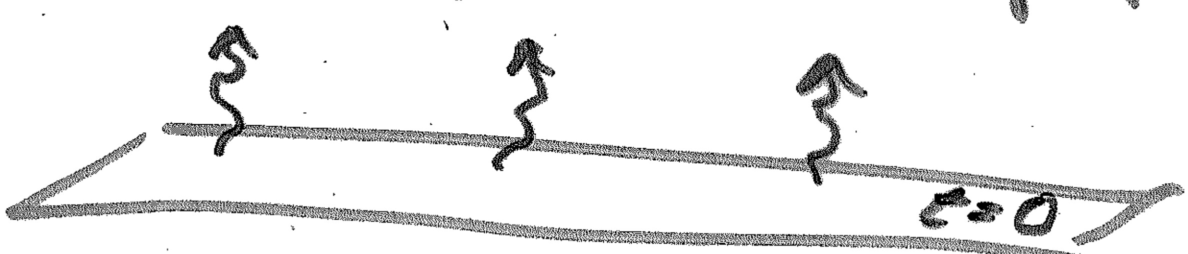
Ω becomes real field in $\check{\mathscr{C}}$ (initial dark matter)

"effectively unique" propagation?

Think of the ordinary wave equation $\Box\varphi = 0$ in flat space-time

$$\Box = \frac{\partial^2}{\partial t^2} - \frac{\partial^2}{\partial x^2} - \frac{\partial^2}{\partial y^2} - \frac{\partial^2}{\partial z^2}$$

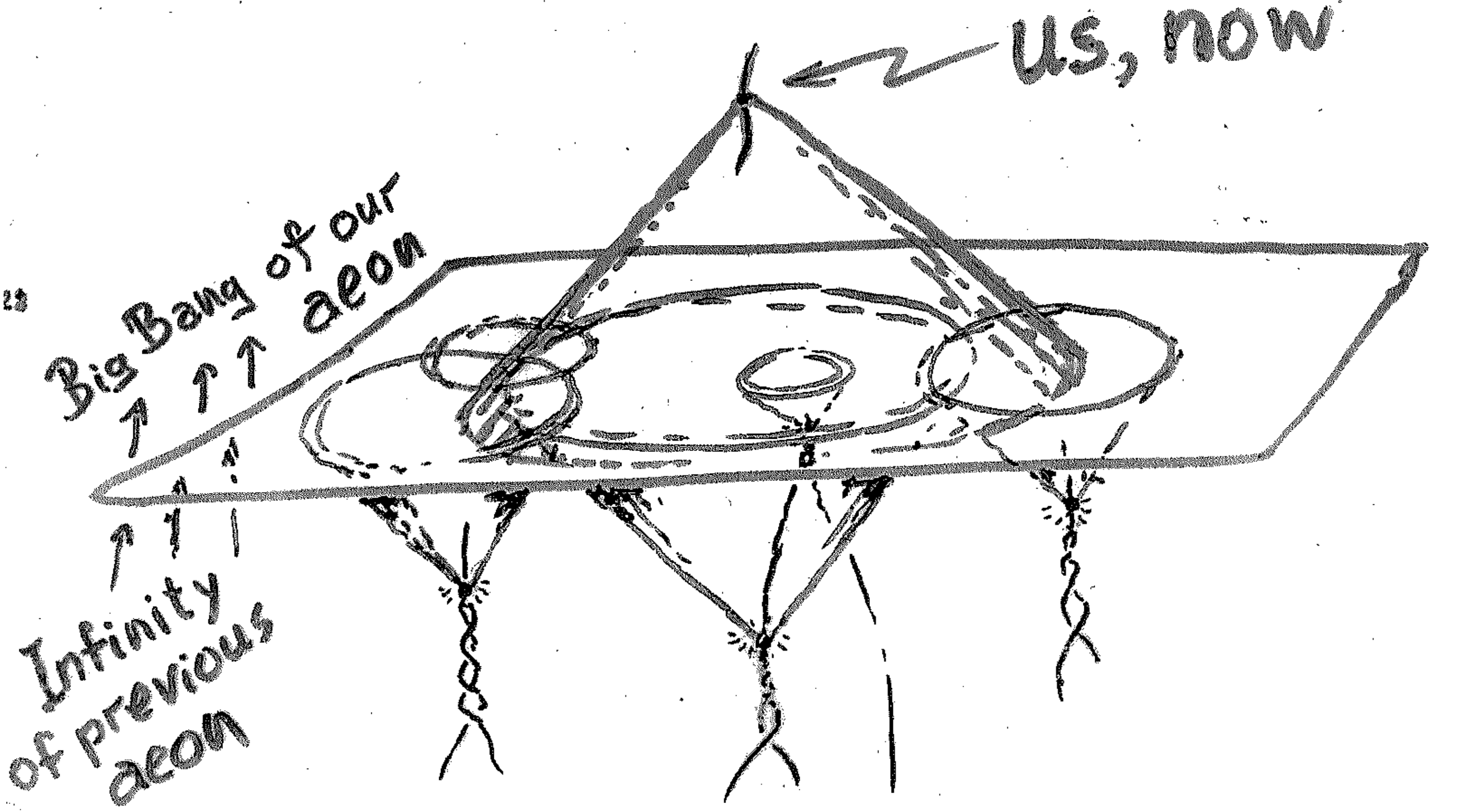
If we know φ and $\dot{\varphi}$ $\left(= \frac{\partial \varphi}{\partial t}\right)$ at $t = 0$, then unique propn.



But if we know $\dot{\varphi}$ and $\ddot{\varphi}$, then non-uniqueness of $\varphi \to \varphi + \psi$ where $\psi(x,y,z)$ satisfies $\nabla\psi = 0$

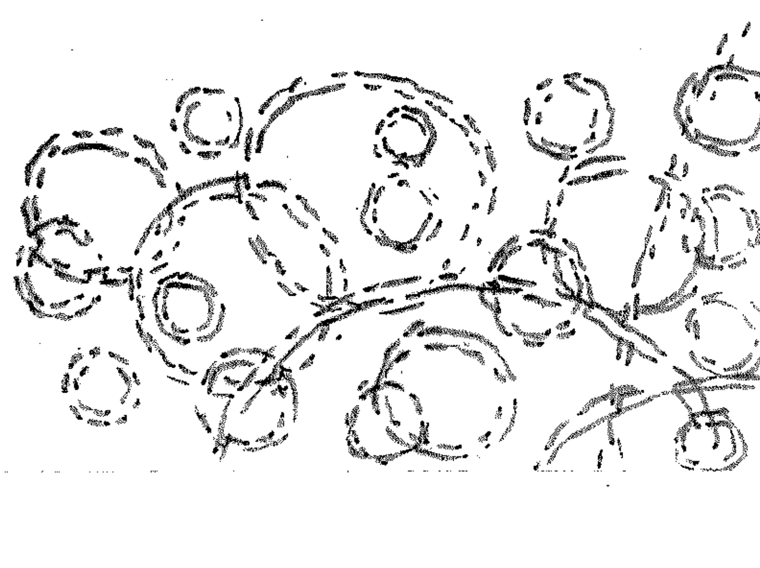
It's similar for ω propagating across $\mathscr{X}$. "Symmetry breaking" Related to Higgs field??

Observational consequence concerning temperature/density variations in Cosmic Microwave Background

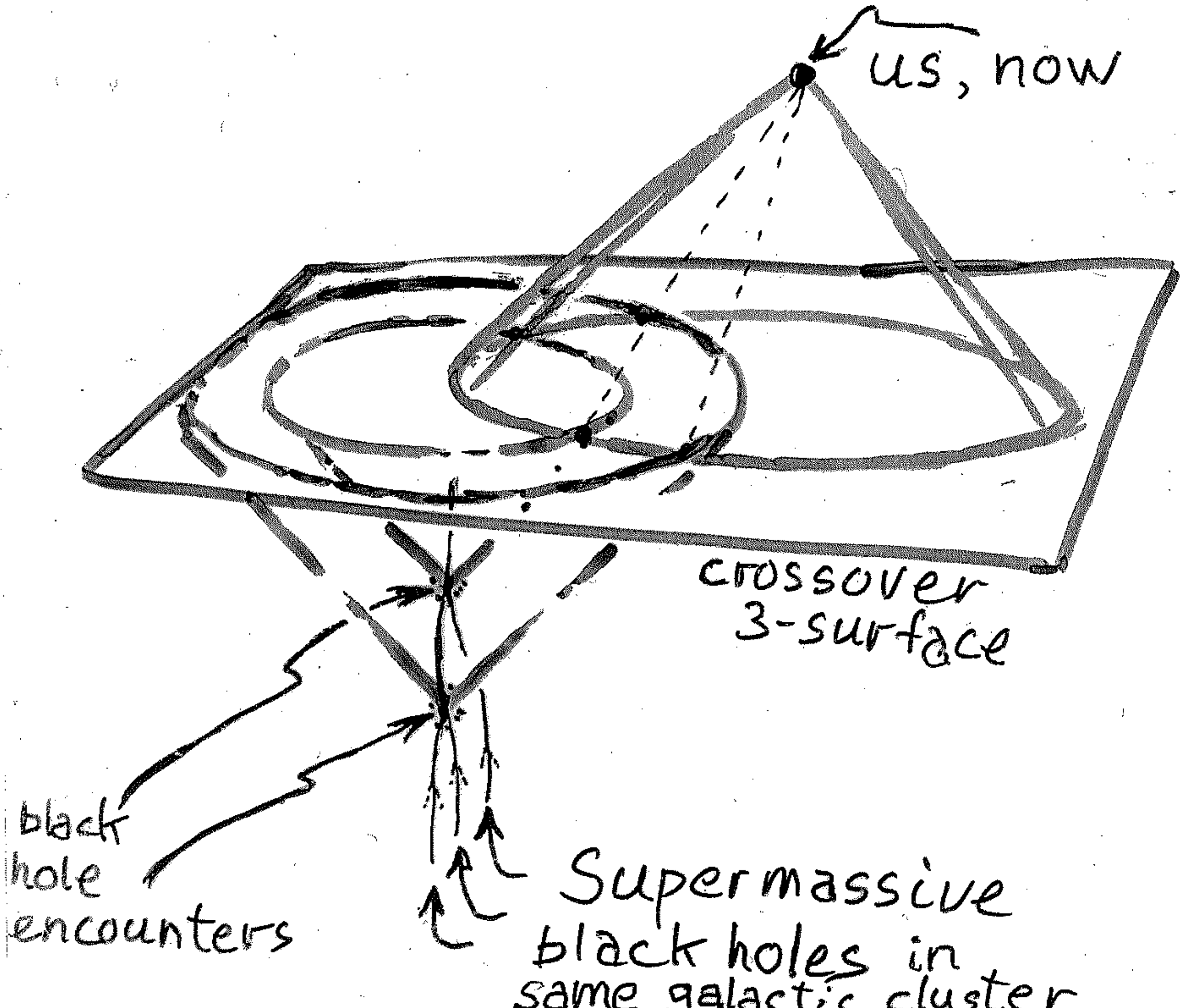


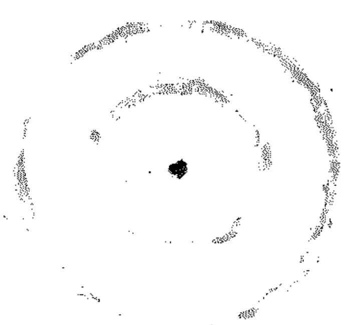
Think of ripples on a pond, caused by raindrops which have recently stopped falling.

Pattern of ripples looks random at first, but can be analysed into circles by statistical analysis.



Can we "see" through into the aeon prior to ours?

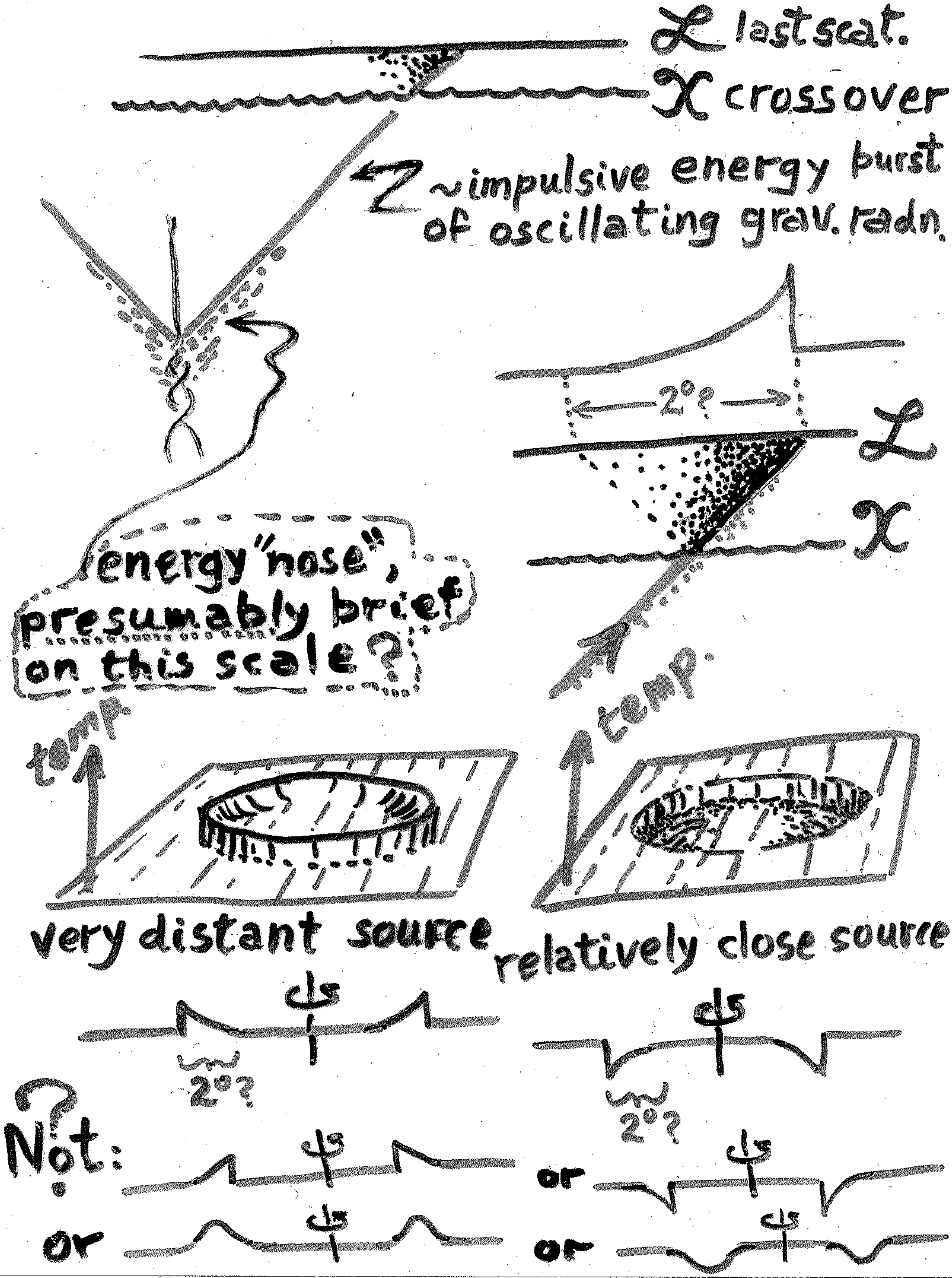




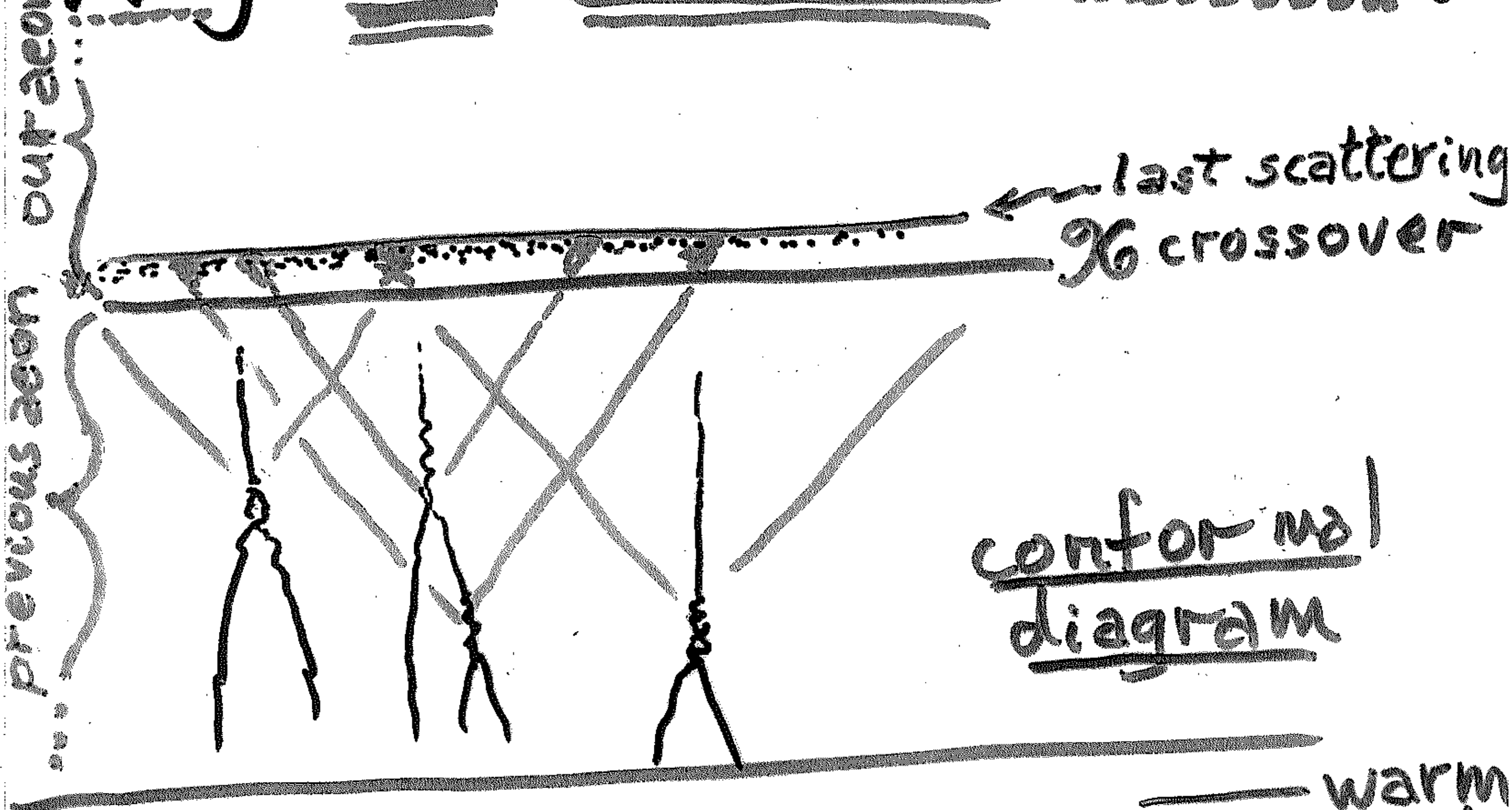
- atypical temperature
  ↳ better diagnostic
- low variance concentric rings

V. Gurzadyan

On the Shape of the Signal

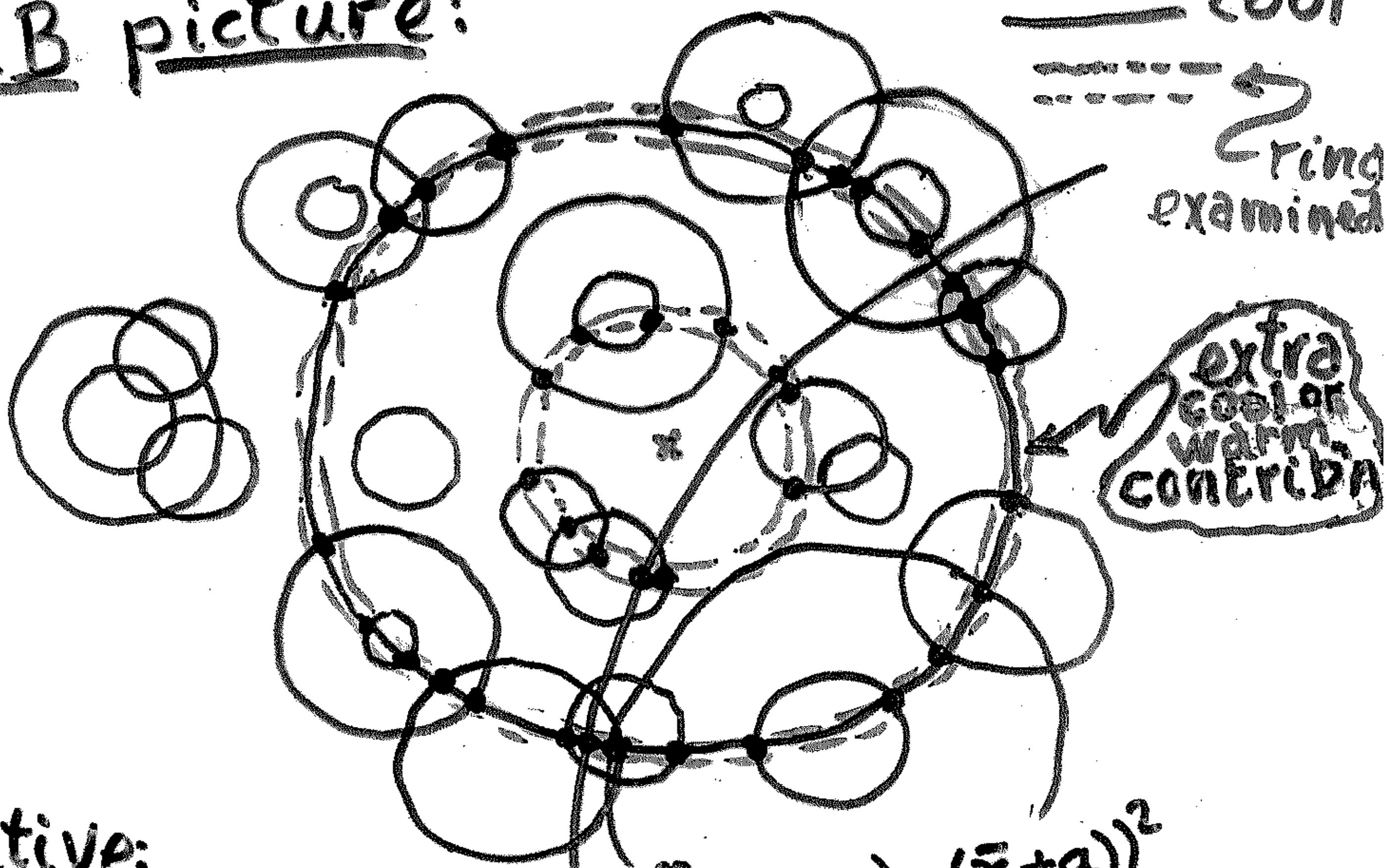


Why low variance circles?



conformal diagram

CMB picture:



Additive:

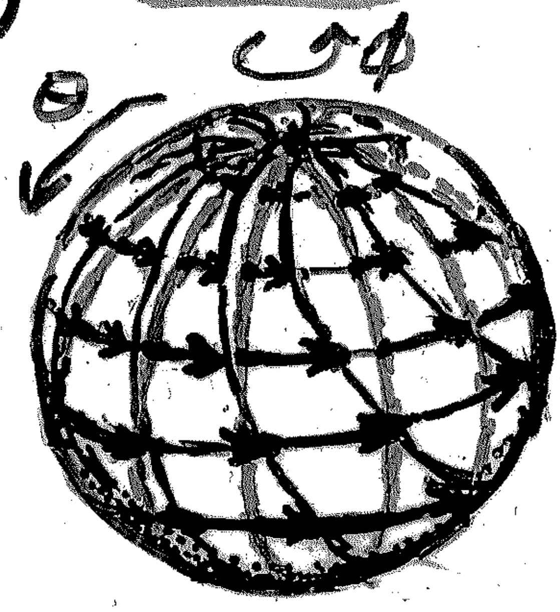
$$\sigma^2 = \frac{1}{n}\sum_{i=1}^{n}(x_i-\bar{x})^2 = \frac{1}{n}\sum_{i=1}^{n}((x_i+a)-(\bar{x}+a))^2$$

Averaged:

$$\frac{1}{n}\sum_{i=1}^{n}\left(\tfrac{1}{2}(x_i+a)-\tfrac{1}{2}(\bar{x}+a)\right)^2 = \left(\tfrac{1}{2}\sigma\right)^2$$

The Sky-Twist Test

(θ, φ) spherical polar angles



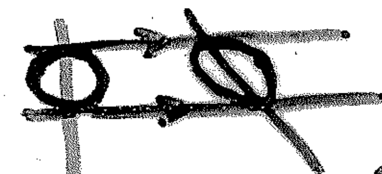
each latitude line rotates by an amount proportional to θ

Area preserving

$$\theta' = \theta$$
$$\phi' = \phi + S\theta$$

(in degrees)

Infinitesimally:



$$\rho = \frac{\text{minor axis}}{\text{major axis}} = \left(\sqrt{1+s^2} - s\right)^2$$

where $s = \frac{1}{180}|S|\sin\theta$

	θ = 90° ± 20°	θ = 90° ± 60°
S = 0	1.000	1.000
S = ±2	0.979	0.989
S = ±5	0.949	0.973
S = ±10	0.901	0.946
S = ±20	0.812	0.895
S = ±40	0.661	0.801
S = ±80	0.444	0.643