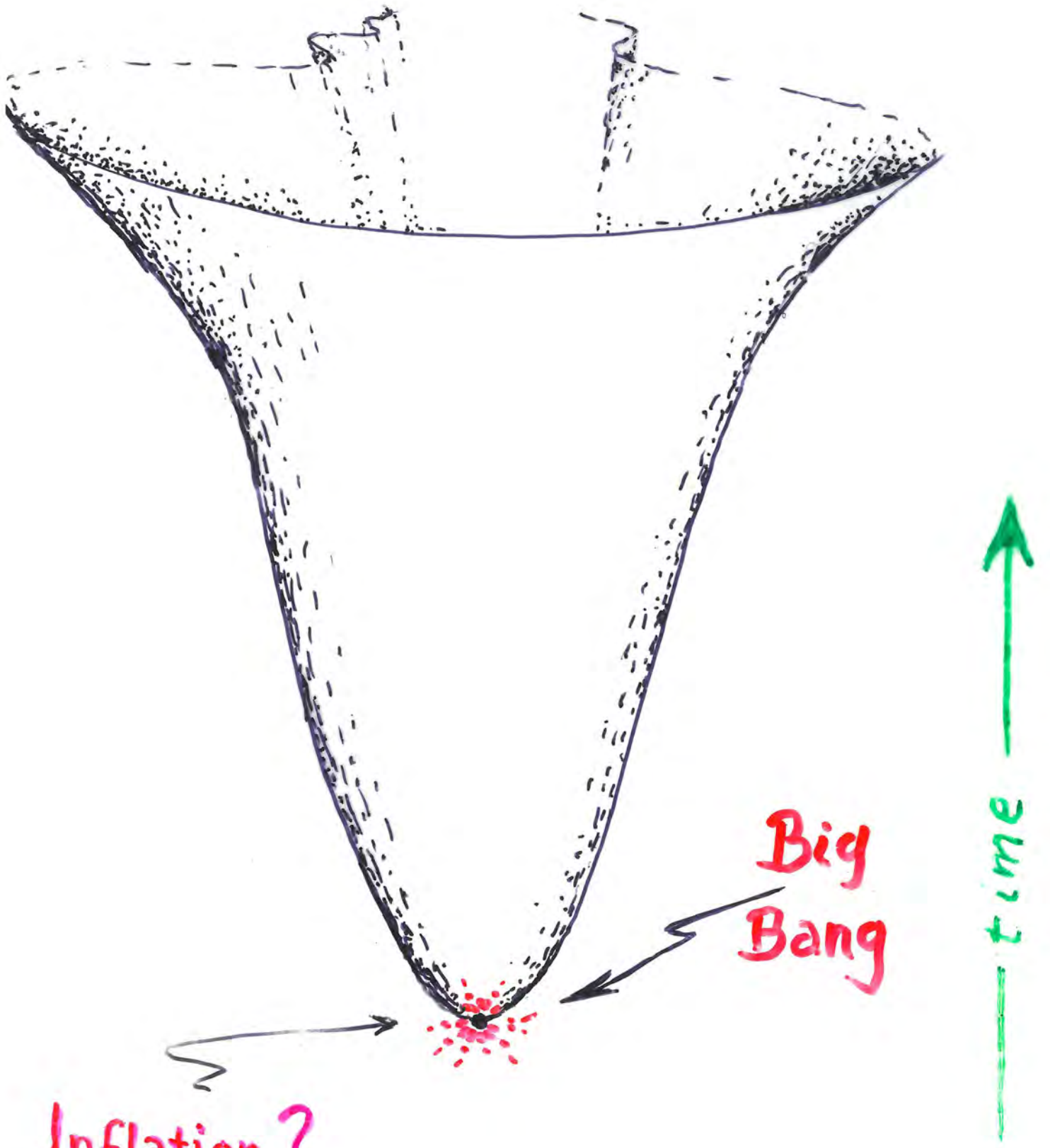
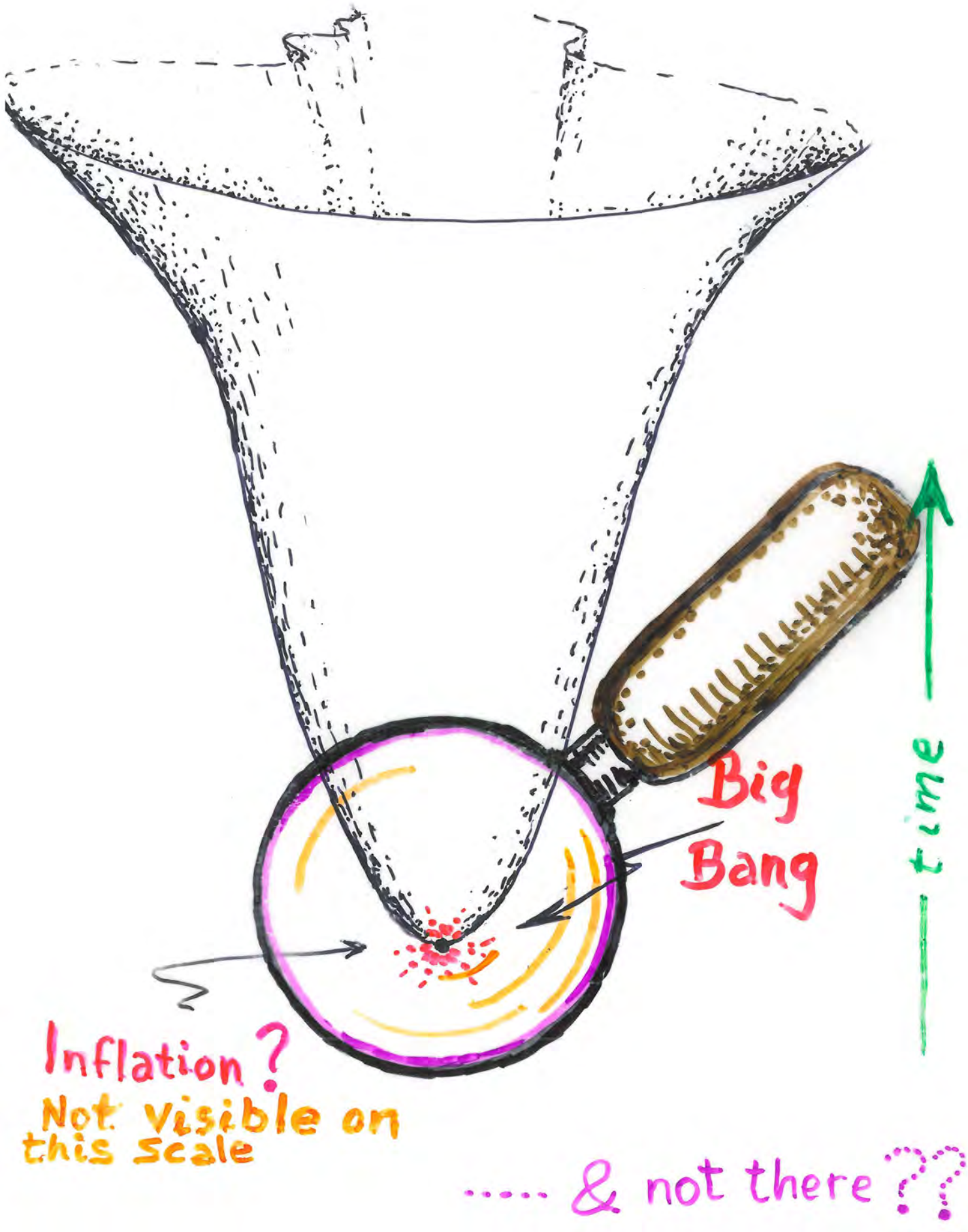
Dark Energy, Dark Matter, & Black Holes, as Essential Ingredients of a New Cyclic Theory of the UNIVERSE

Vienna, November 2012

Dark Matter, Dark Energy, Black Holes & Quantum Aspects of the Universe


Big Bang
time
Inflation?
Not visible on this scale
..... & not there??


Big
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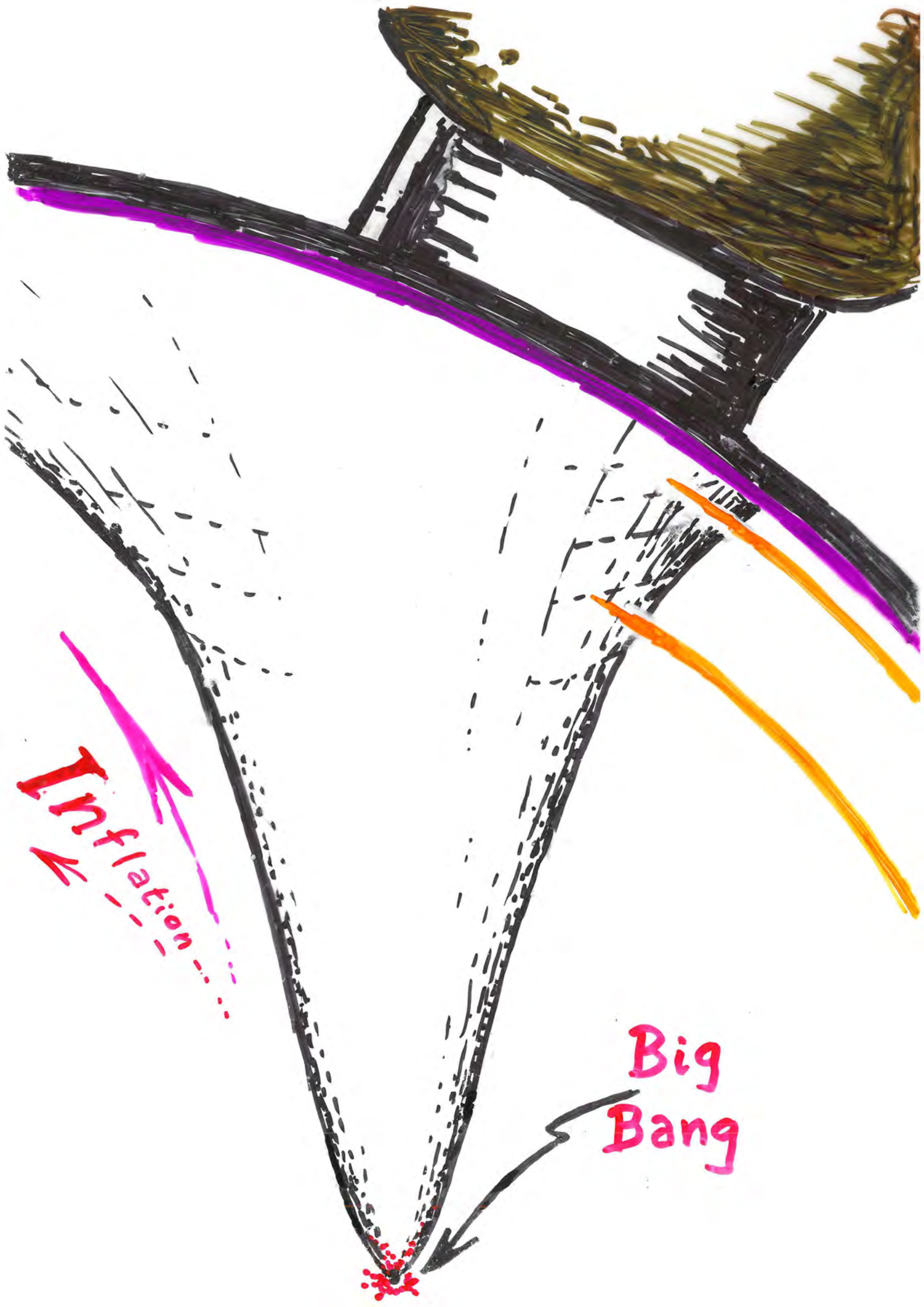
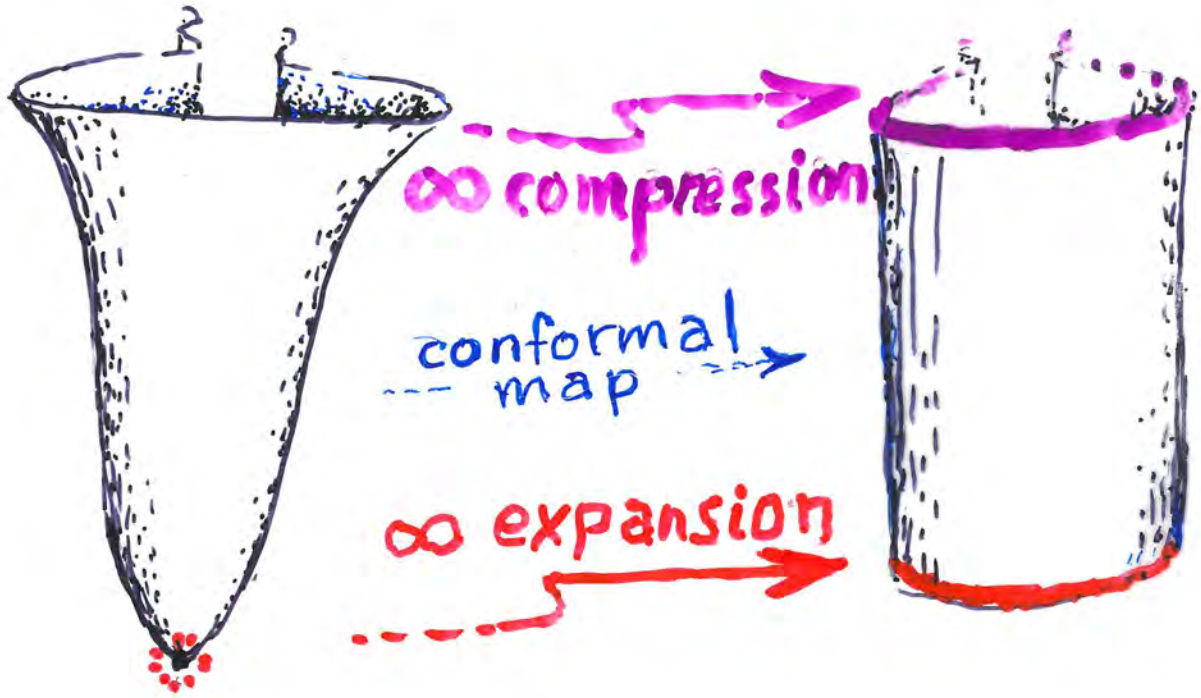
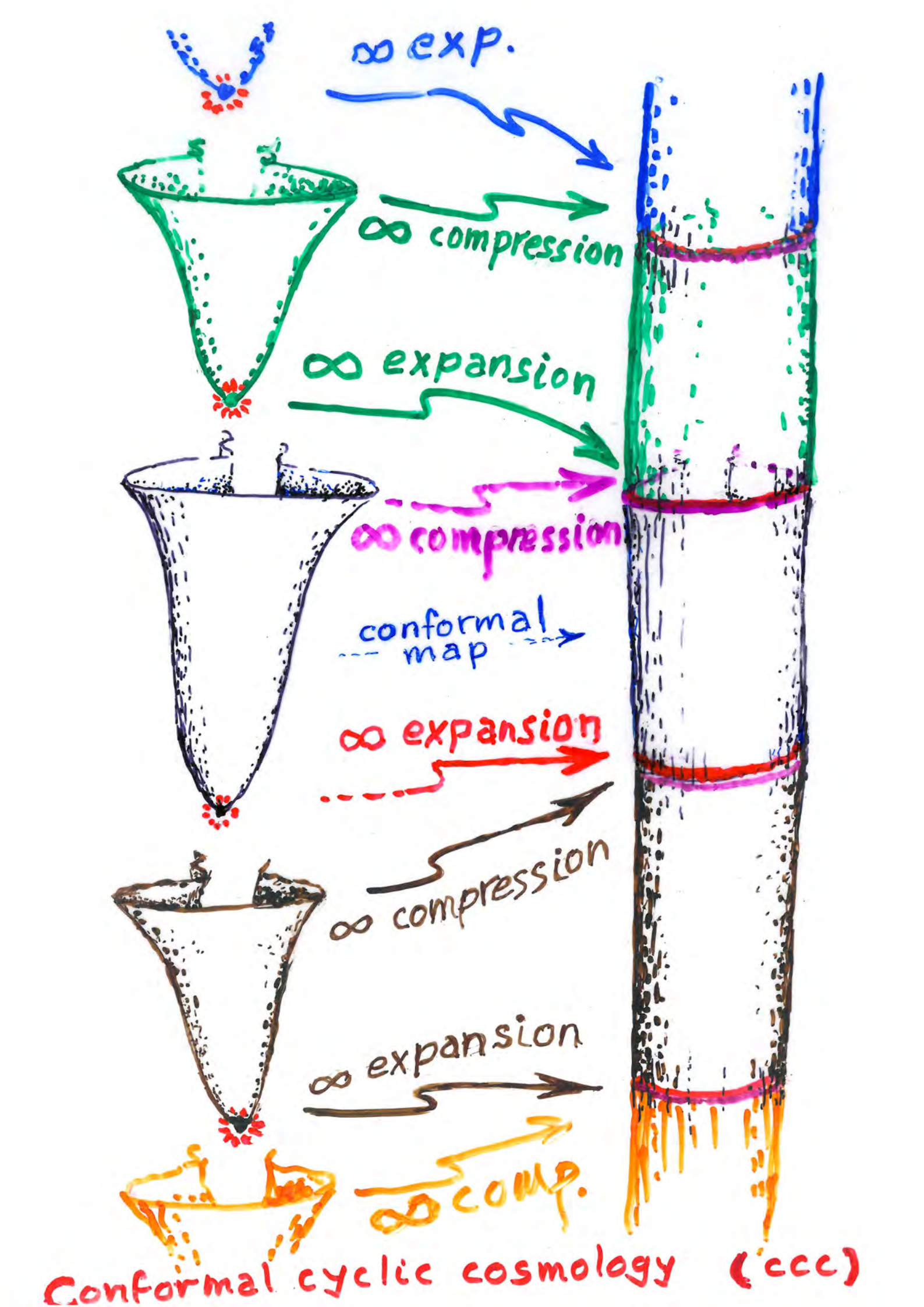

Inflation
Big
Bang

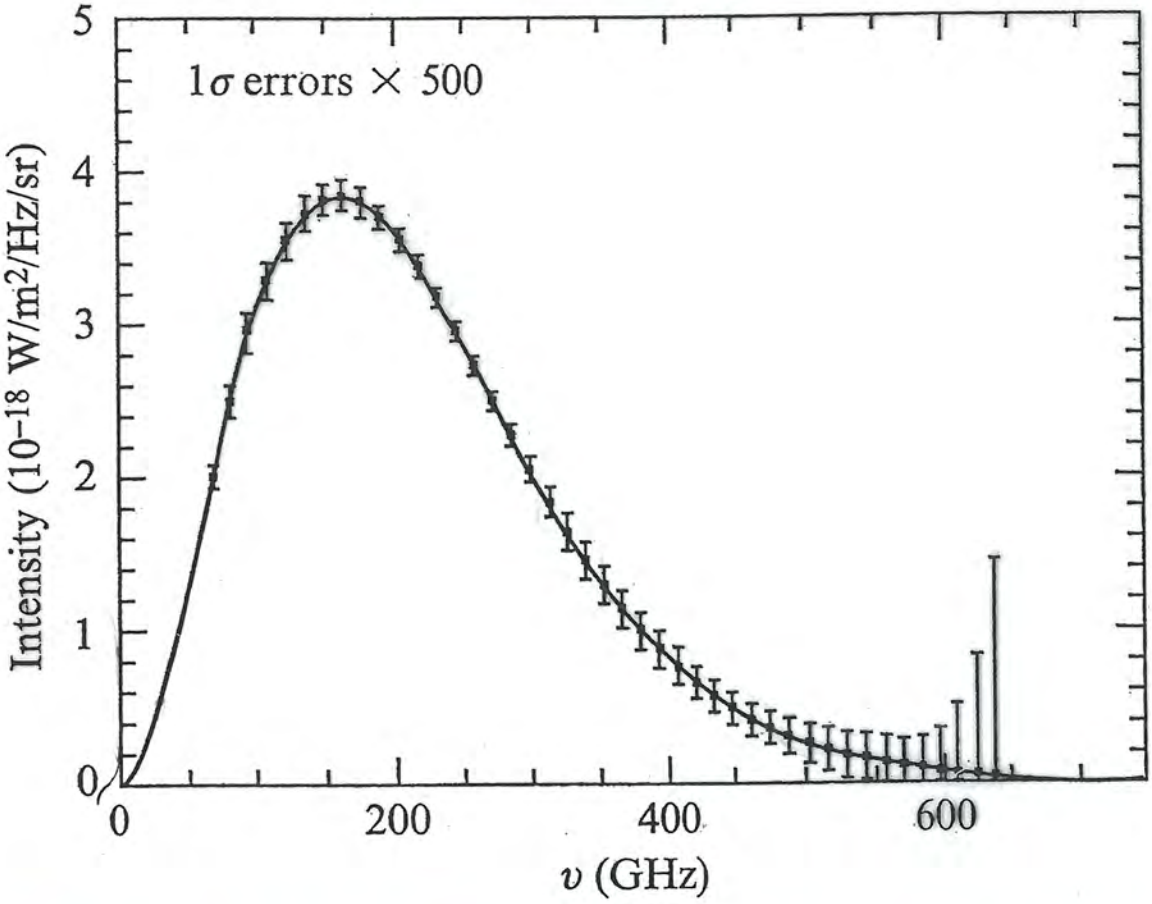

∞ compression
conformal map
∞ expansion



Conformal cyclic cosmology ('ccc)

Spectrum of the Cosmic Microwave Background

CMB



Note: error bars are exaggerated by a factor of 500.

The solid curve displays the Planck black body spectrum of *thermal equilibrium*.

2nd Law of Thermodynamics

Entropy increases with time

= "disorder" (roughly speaking)

Gas in a box

time increases →

entropy increases →

Gravitating bodies

Maximum entropy:

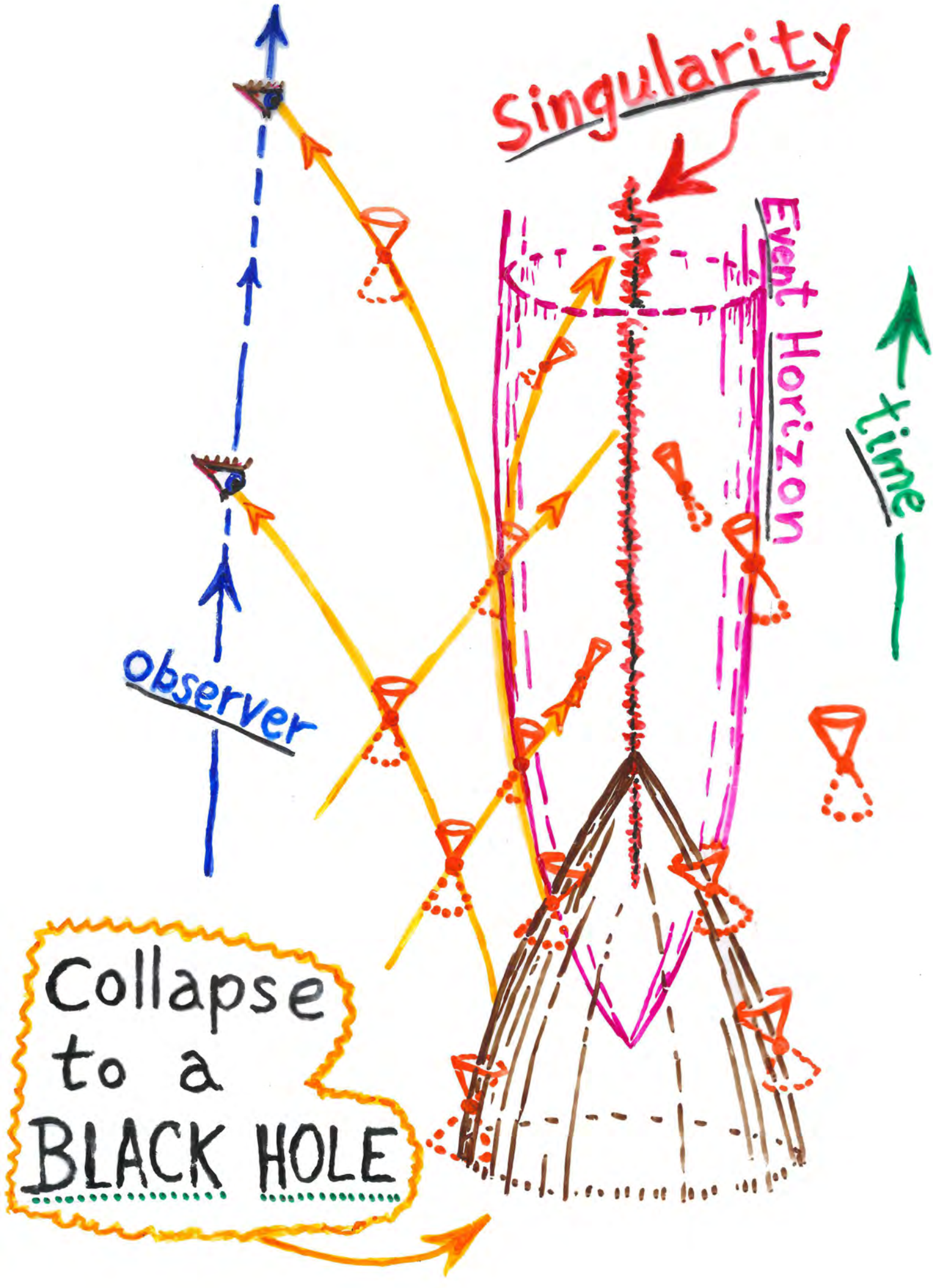
BLACK HOLE

Energy: conserved

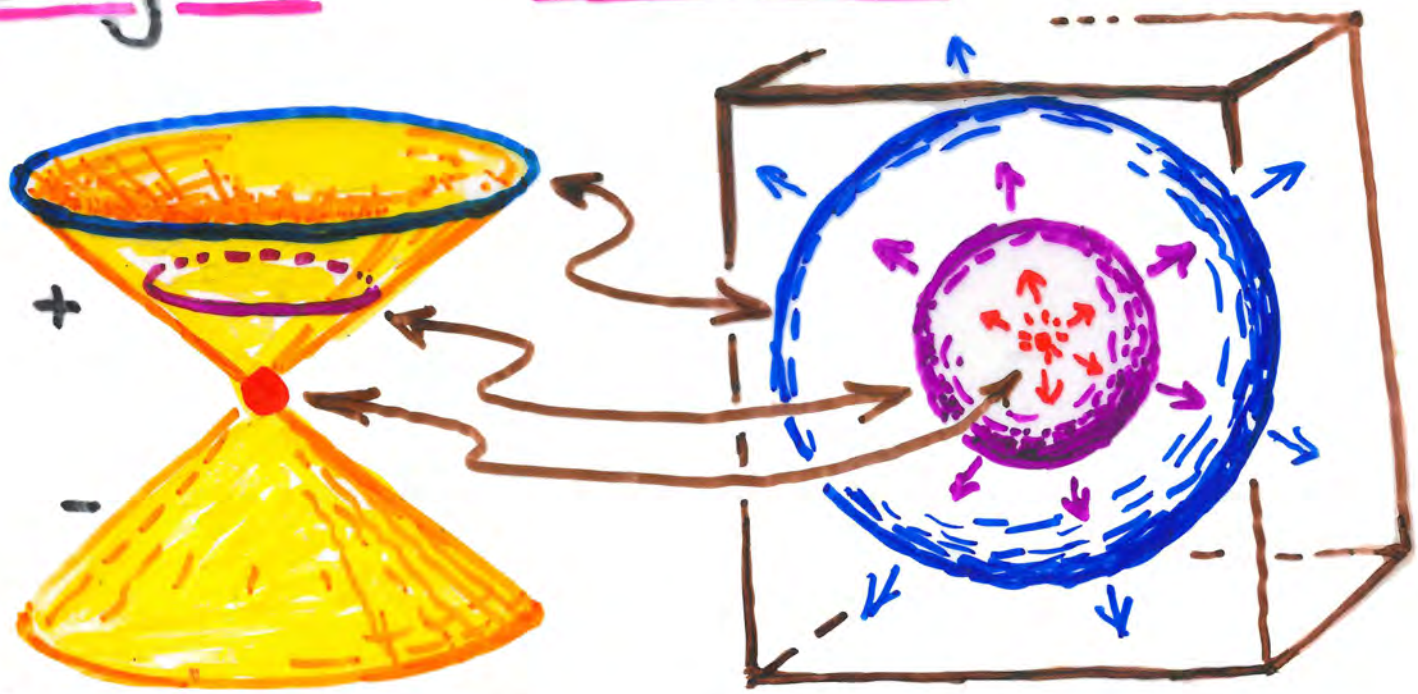
As much energy goes back into space from the earth as comes in from the sun

Entropy: can keep it down
by absorbing few high-energy photons
& emitting many low-energy photons

Sun is hot spot in dark sky
From GRAVITATIONAL clumping

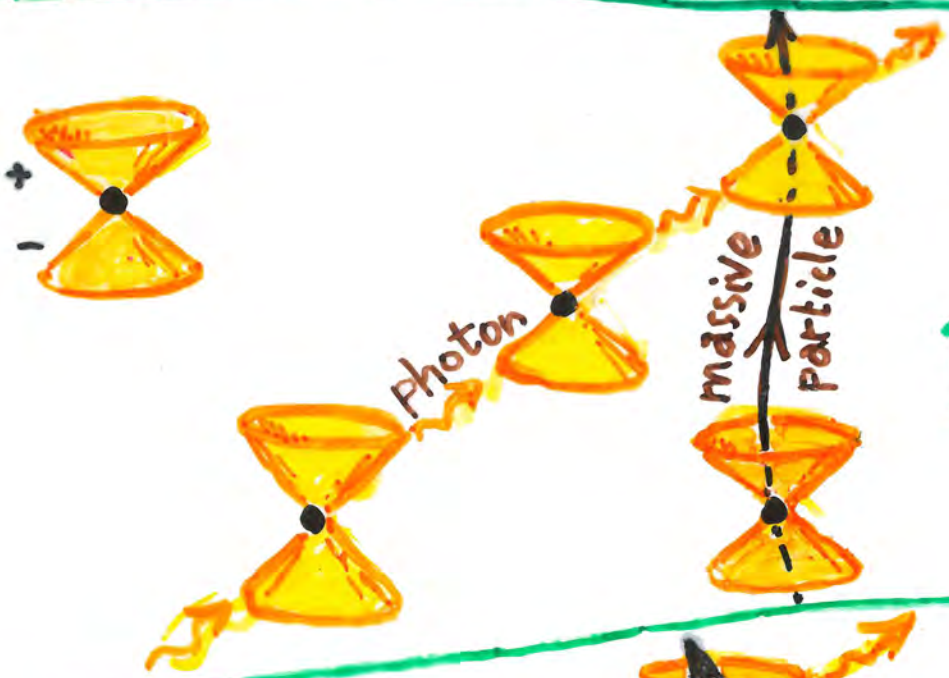

Singularity
Event Horizon
time
observer
Collapse to a BLACK HOLE

Light cones

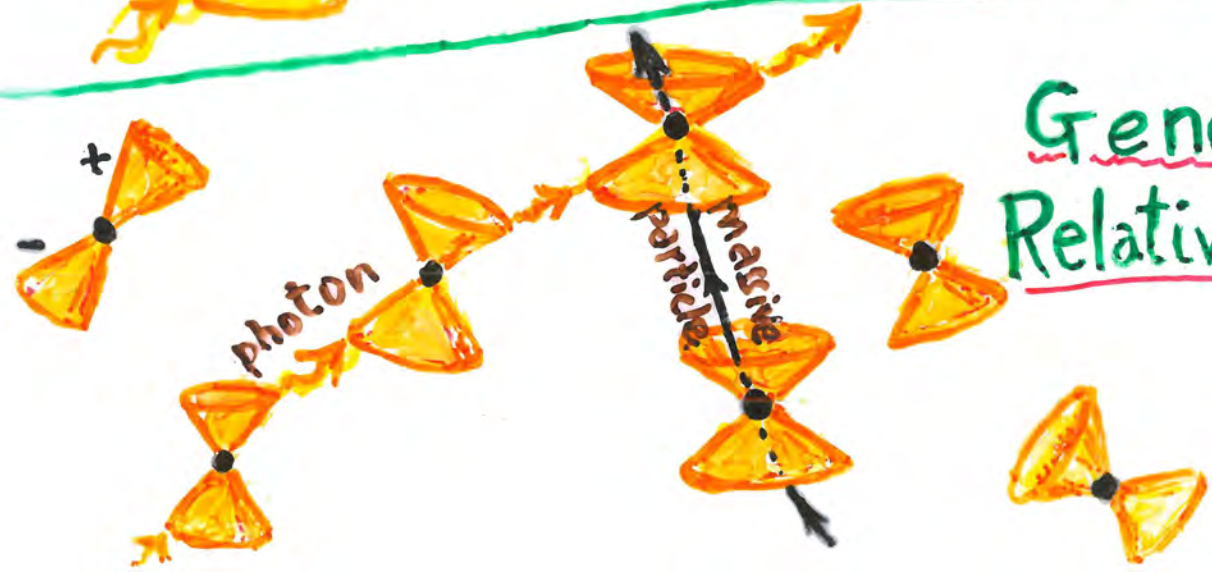


Space-time picture

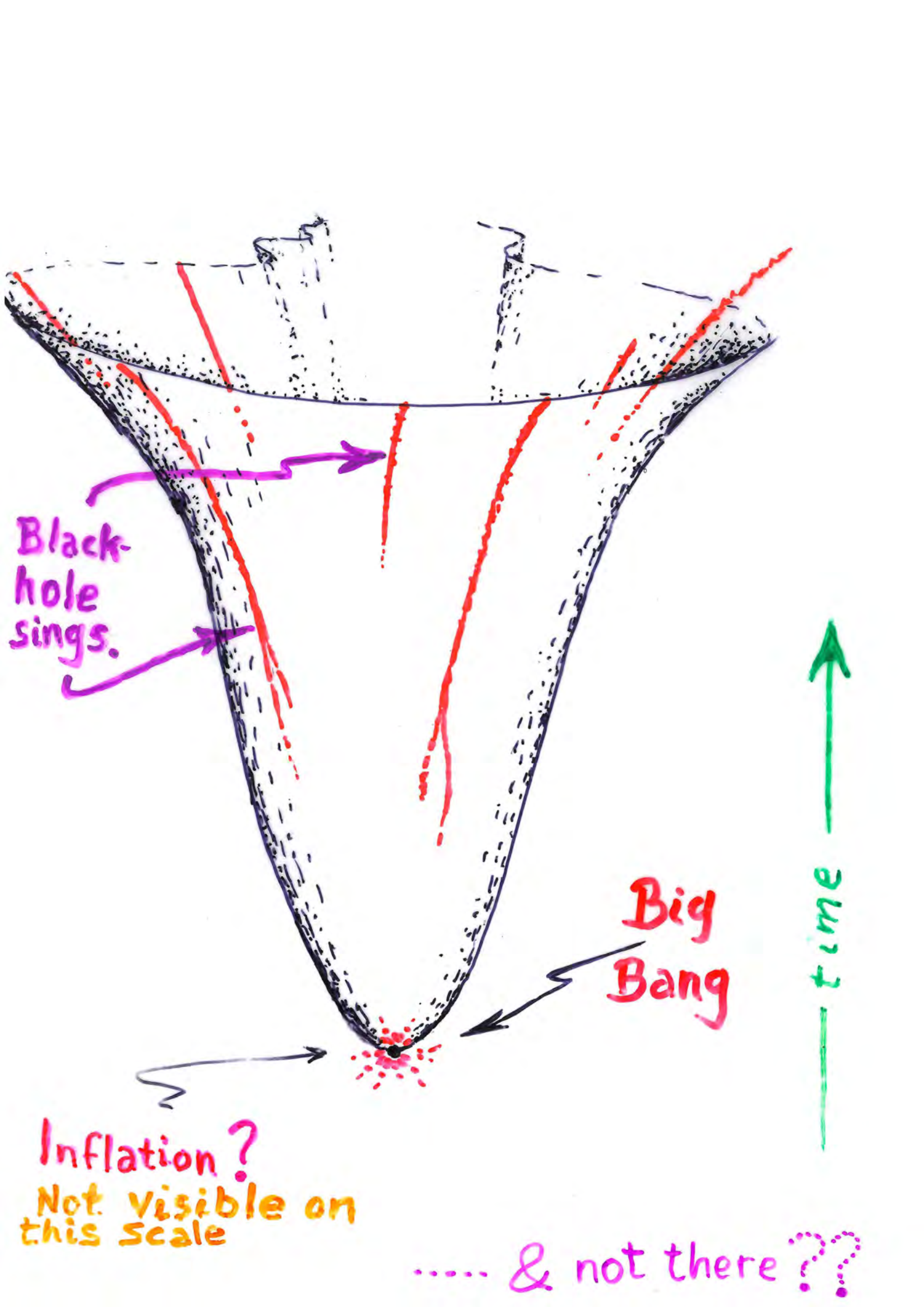
Space picture



Special Relativity



General Relativity


Black-
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sings.
Big
Bang
time
Inflation?
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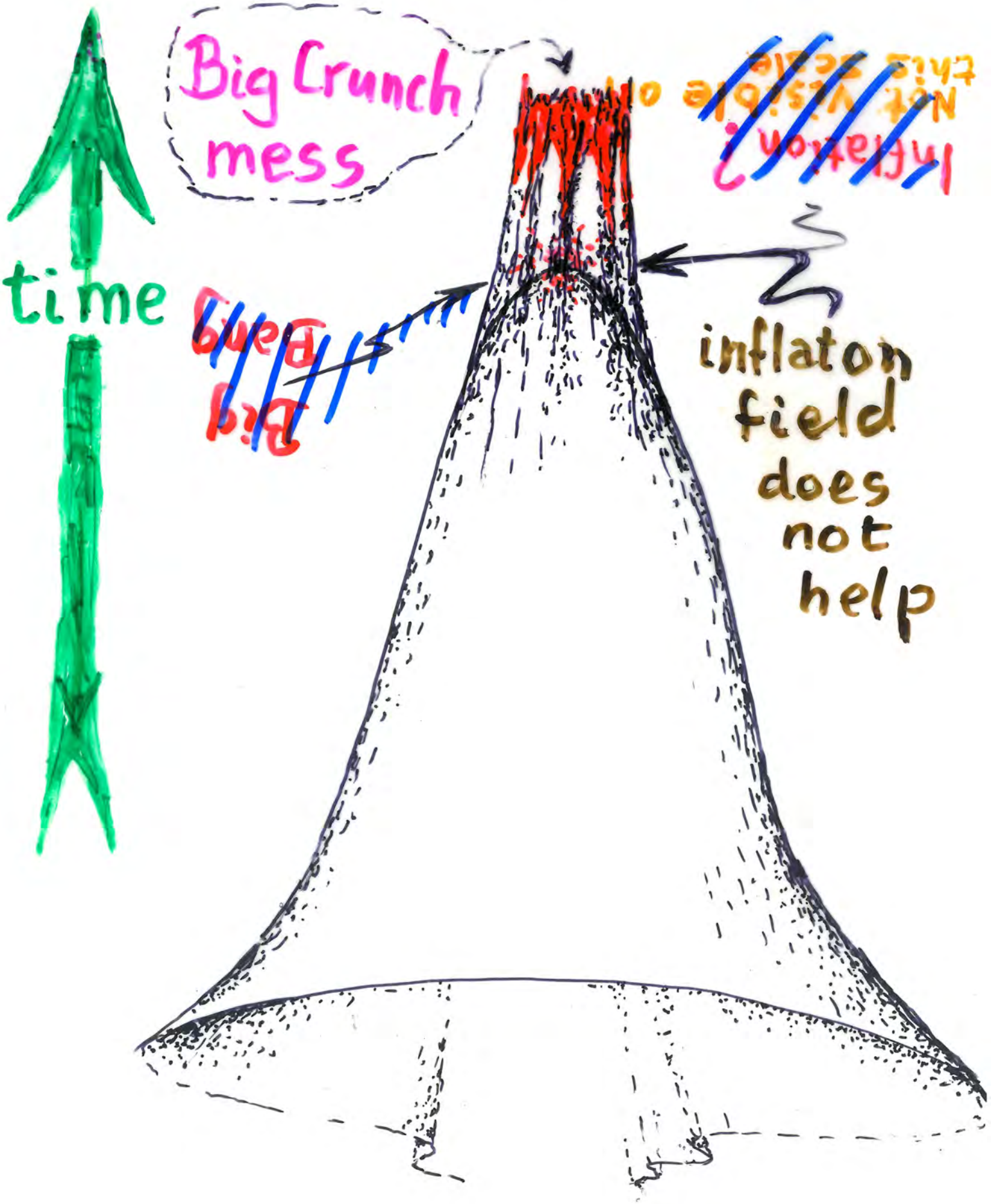
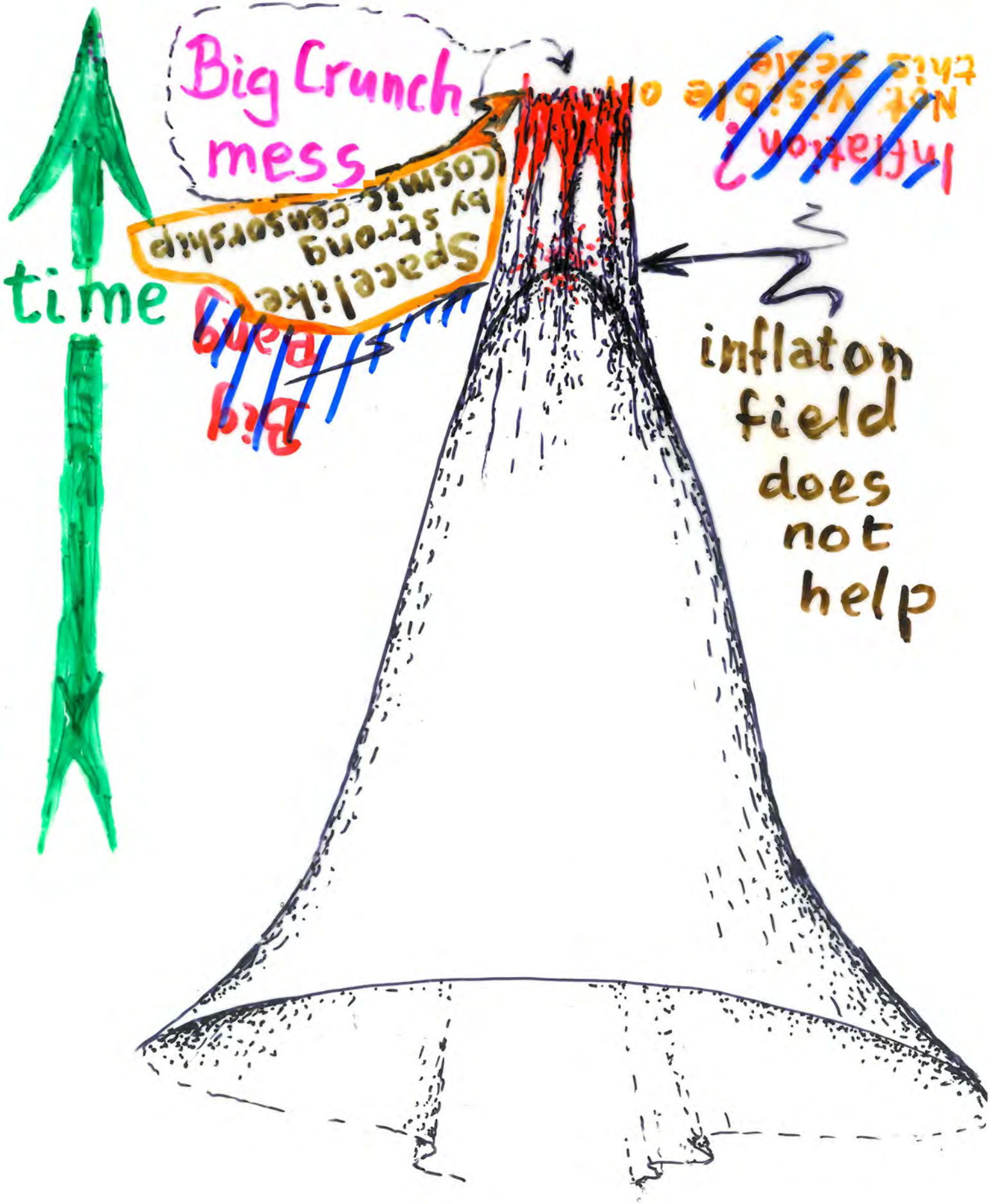

Big Crunch
mess
time
inflaton
field
does
not
help


Big Crunch
mess
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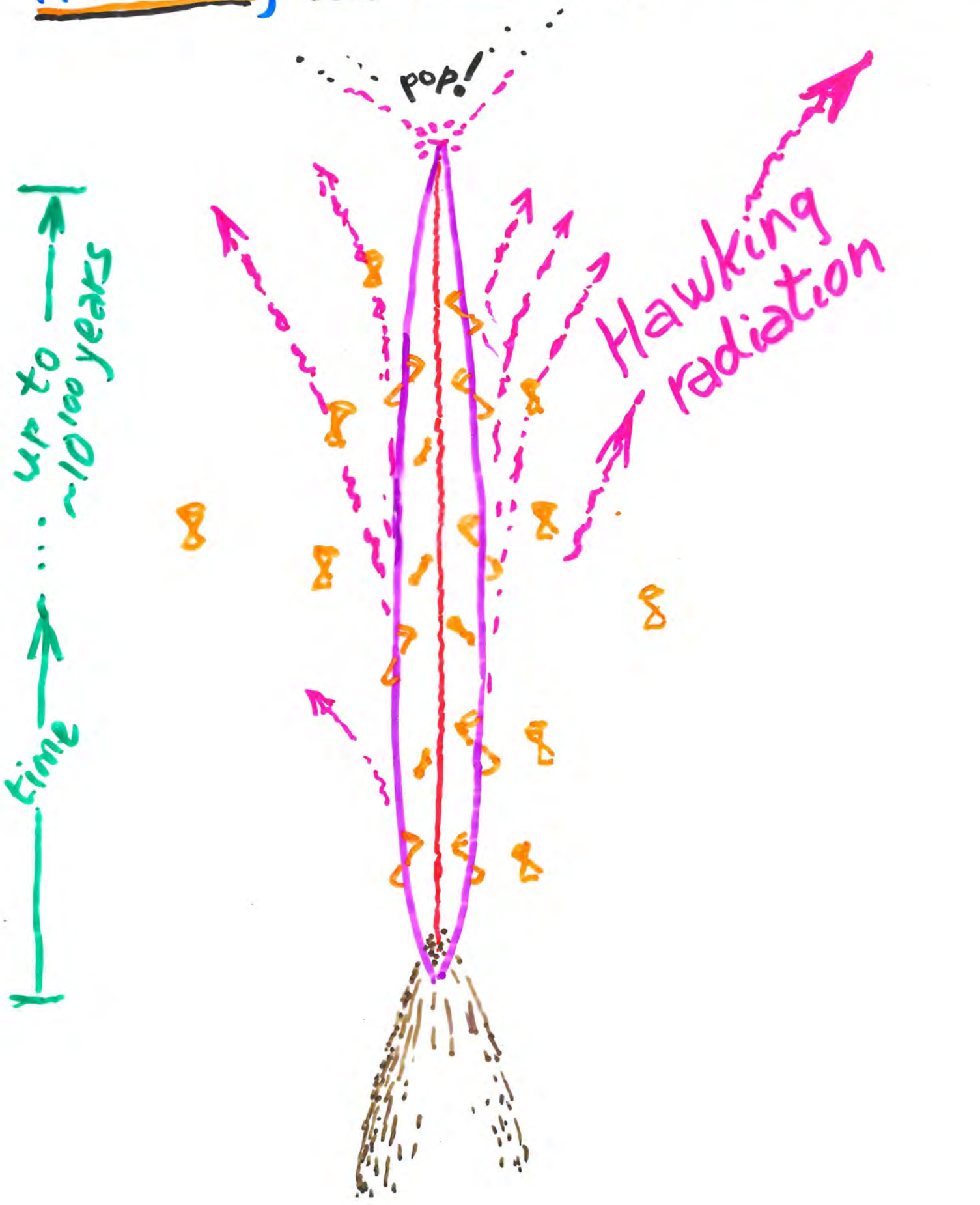
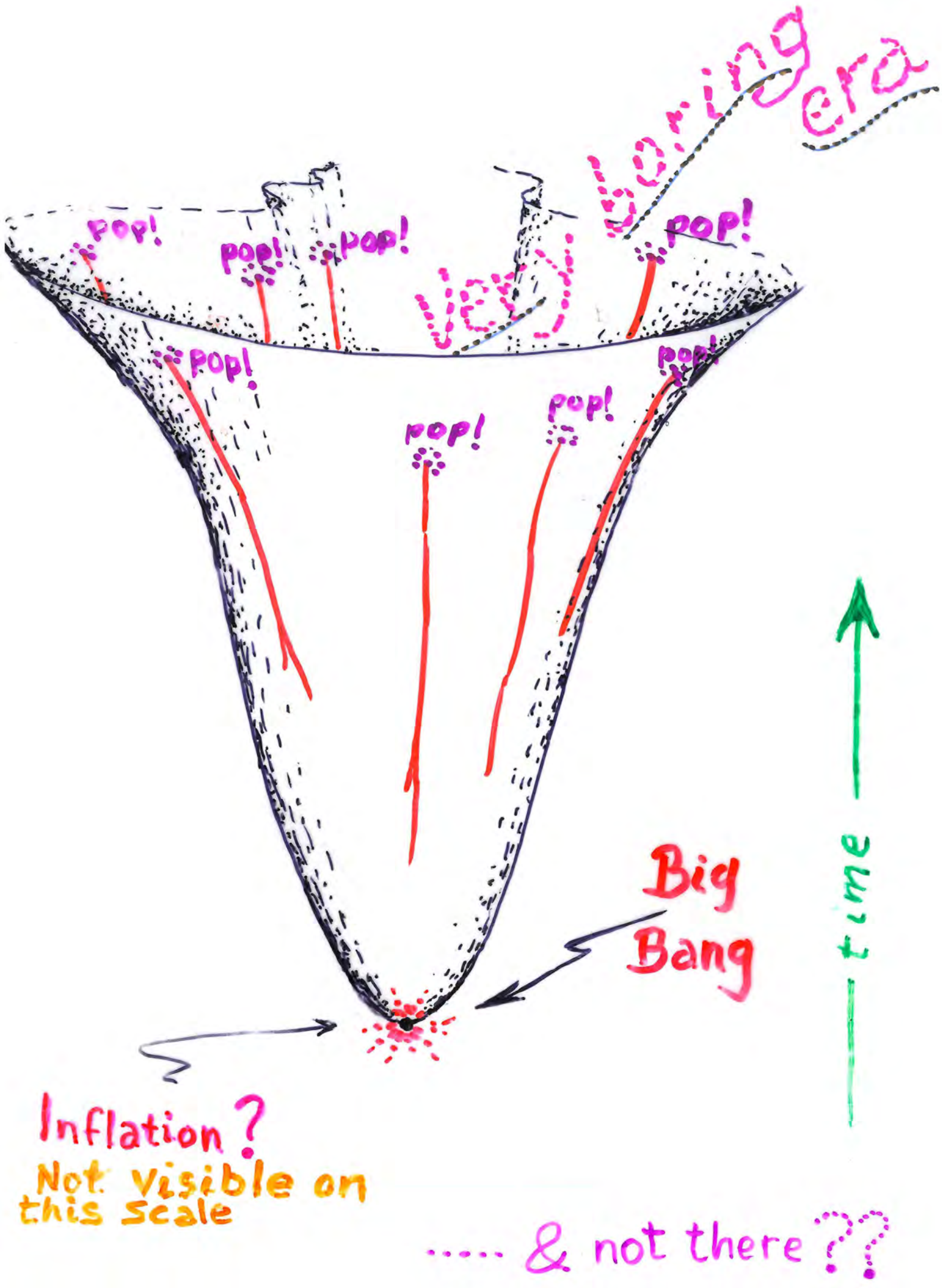
The Big Bang must have been subject to a HUGE constraint, due to suppression of gravitational degrees of freedom — to more than 1 part in $10^{10^{124}}$

(from Bekenstein–Hawking black hole entropy)

This is a somewhat awkward condition to state in a precise mathematical way ("Weyl curvature hypothesis") Fortunately Paul Tod (2003) came up with an elegant mathematical proposal:

Hawking evaporating black hole




very boring era
POP!
POP!
POP!
POP!
POP!
POP!
POP!
POP!
POP!
Big Bang
time
Inflation?
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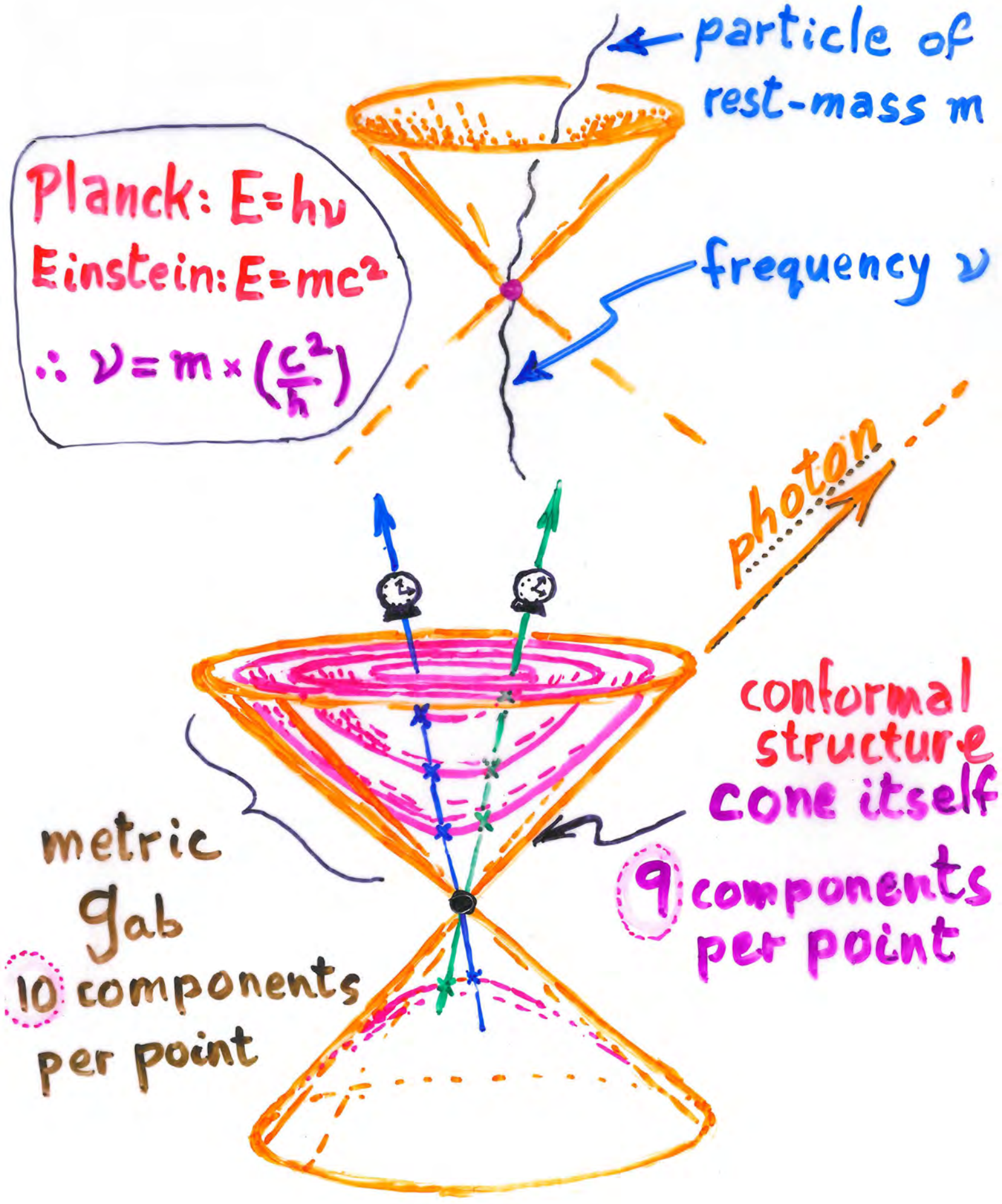
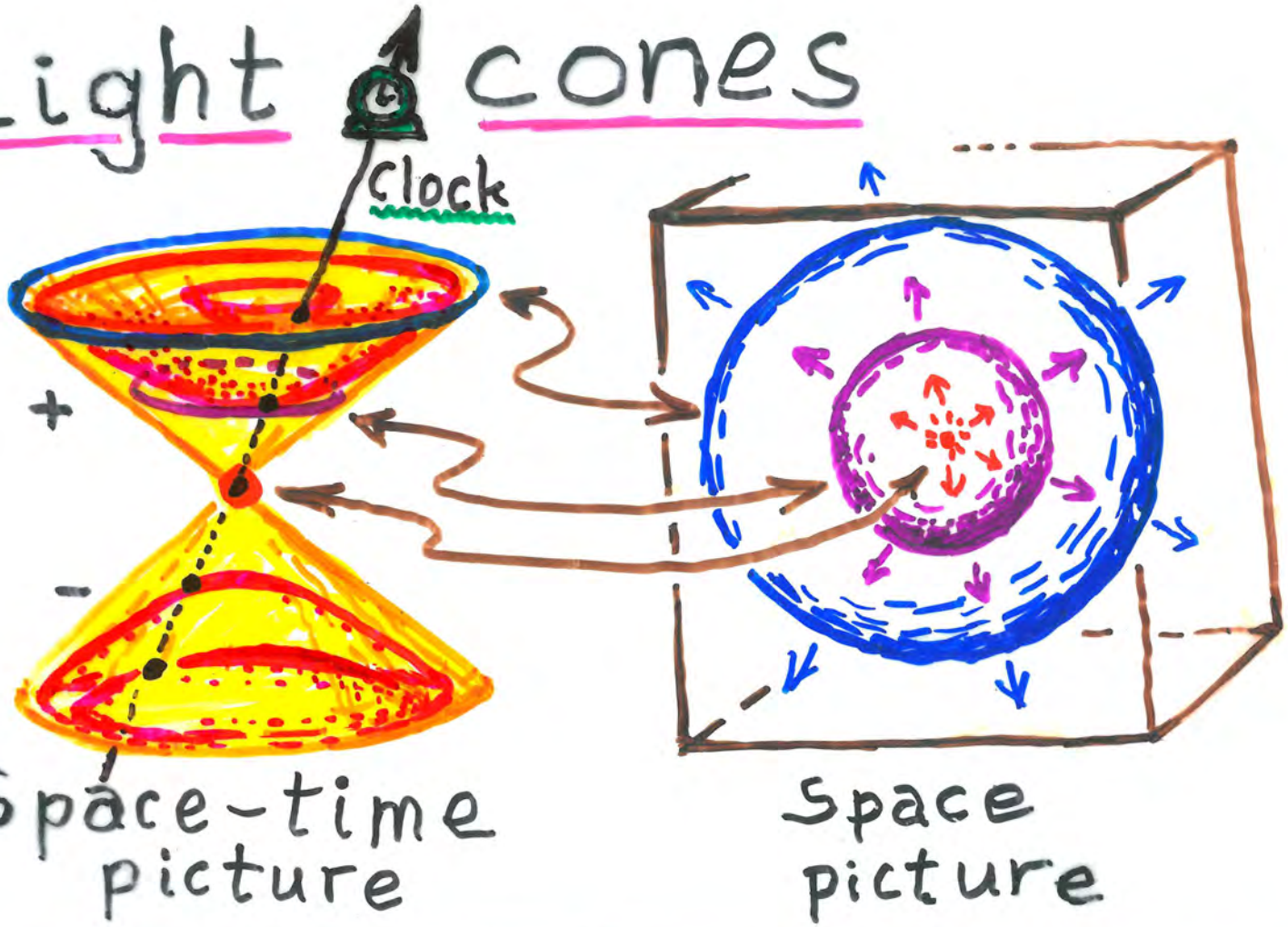

particle of rest-mass m
Planck: $E=h\nu$
Einstein: $E=mc^2$
$\therefore \nu = m \times \left(\frac{c^2}{h}\right)$
frequency ν
photon
conformal structure cone itself
9 components per point
metric g_{ab}
10 components per point

Light cones

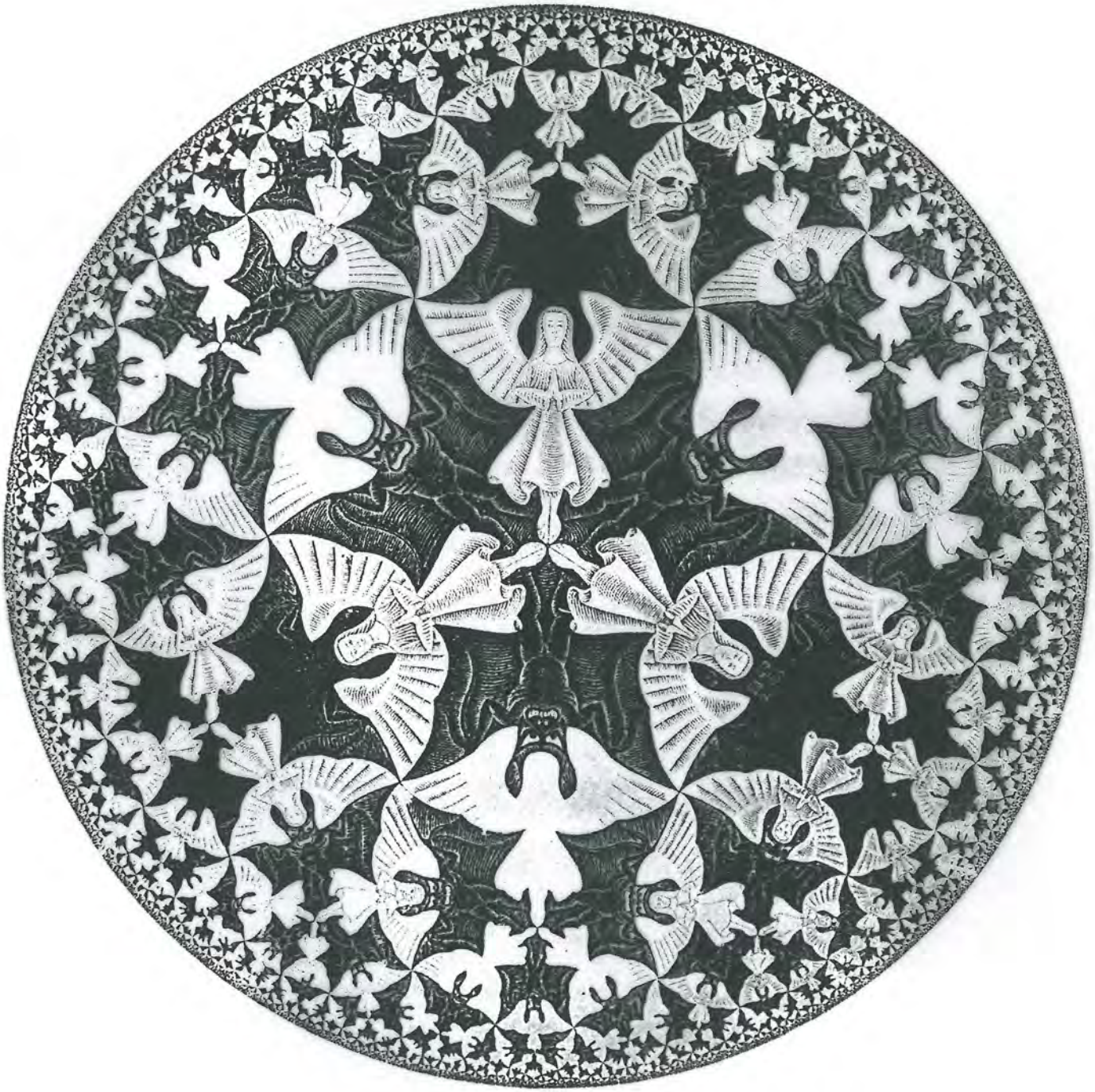


Space-time picture

Space picture

Special Relativity

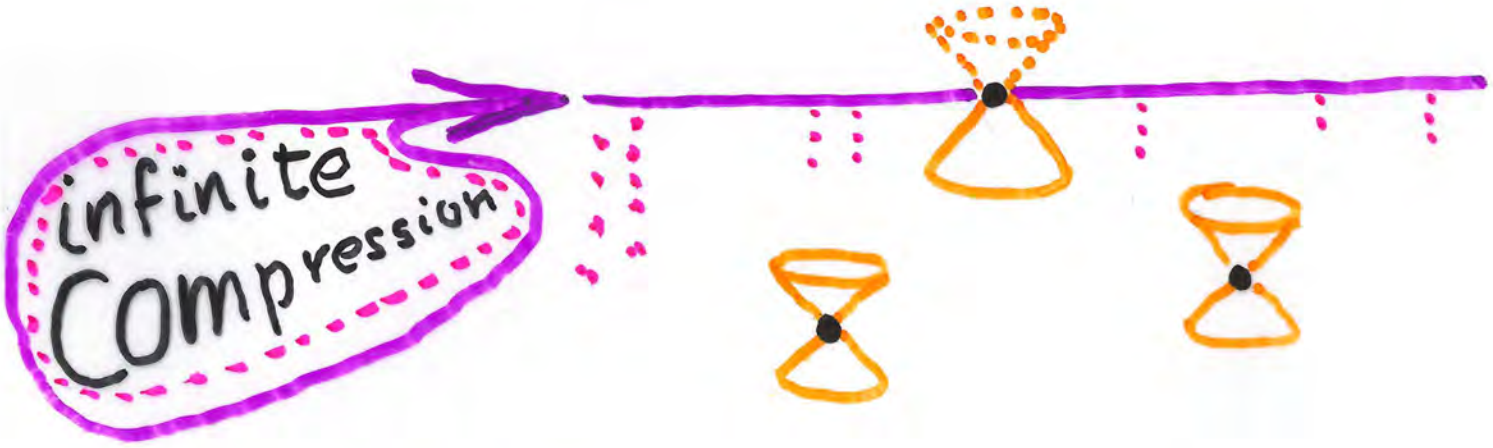
General Relativity



12. CIRCLE LIMIT IV (*Heaven and Hell*), *woodcut printed from two blocks, diam. 42 cm., 1960.*

Starting from the six central figures — three white angels and three black devils — the circle can be divided into six sectors in which alternately the white and the black figures function as 'background' and as 'object' (see captions of prints 1 and 2). In three sectors the white angels prevail, in three others the black devils. The notions of 'heaven' and 'hell' constantly alternate, via stages in which angel and devil figures are equivalent.

K<0



The extremely remote future

Much matter collapses to black holes which eventually evaporate away by Hawking's process. $\sim 10^{100}$ years
Mainly photons left; remaining massive particles (e.g. electrons) lose their mass eventually through a proposed "anti-Higgs process".
With only massless ingredients left, there is no way to build a clock! Eternity is as nothing for a massless particle like a photon

Conformal geometry!

Note: infinity is spacelike for $\Lambda > 0$

Mathematical trick?

The Big Bang must have been subject to a HUGE constraint, due to suppression of gravitational degrees of freedom—to more than 1 part in $10^{10^{124}}$

(from Bekenstein–Hawking black hole entropy)

This is a somewhat awkward condition to state in a precise mathematical way ("Weyl curvature hypothesis") Fortunately Paul Tod (2003) came up with an elegant mathematical proposal: that the space-time be extendible conformally (i.e. as a ligh-cone structure) to BEFORE the Big Bang

Is this just a mathematical trick?

Note: near the Big Bang, temperatures get so high (≫ LHC energies) that rest-mass effectively disappears .....≫ Higgs energy!

The Big Bang must have been subject to a **HUGE** constraint, due to suppression of gravitational degrees of freedom — to more than **1 part in $10^{10^{124}}$**

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The extremely remote future

to BEFORE the Big Bang

Is this just a mathematical trick?

Note: near the Big Bang, temperatures get so high (⇒ LHC energies) that rest-mass effectively disappears ⇒ finite energy!

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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 holes

As these black holes eventually evaporate away, their lost degrees of freedom no longer contribute to the total entropy value

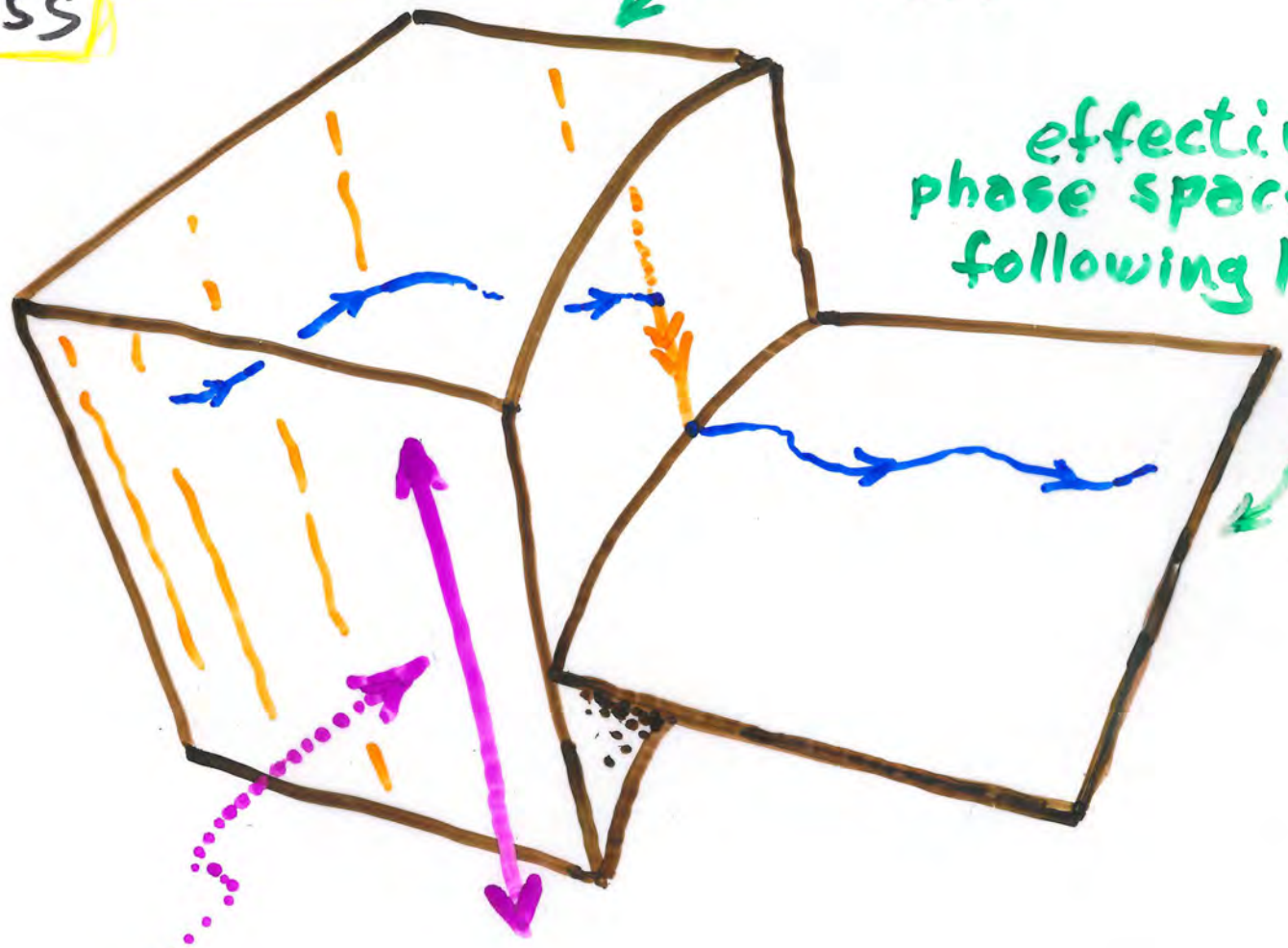
The ZERO of entropy is then re-set

The 2nd Law is "transcended", not violated

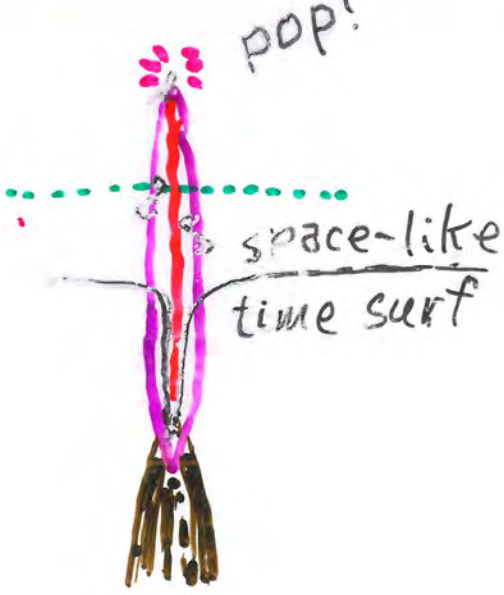
phase space with info. loss

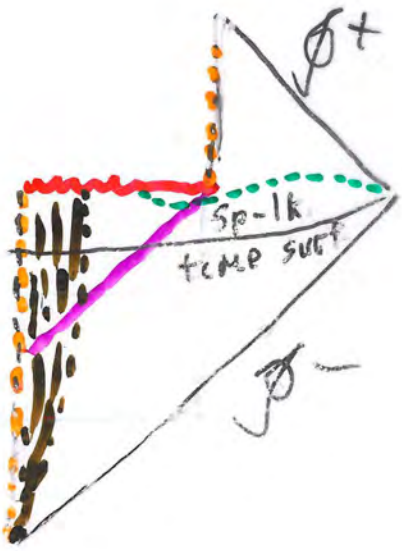
phase space prior to info. loss

effective phase space following loss

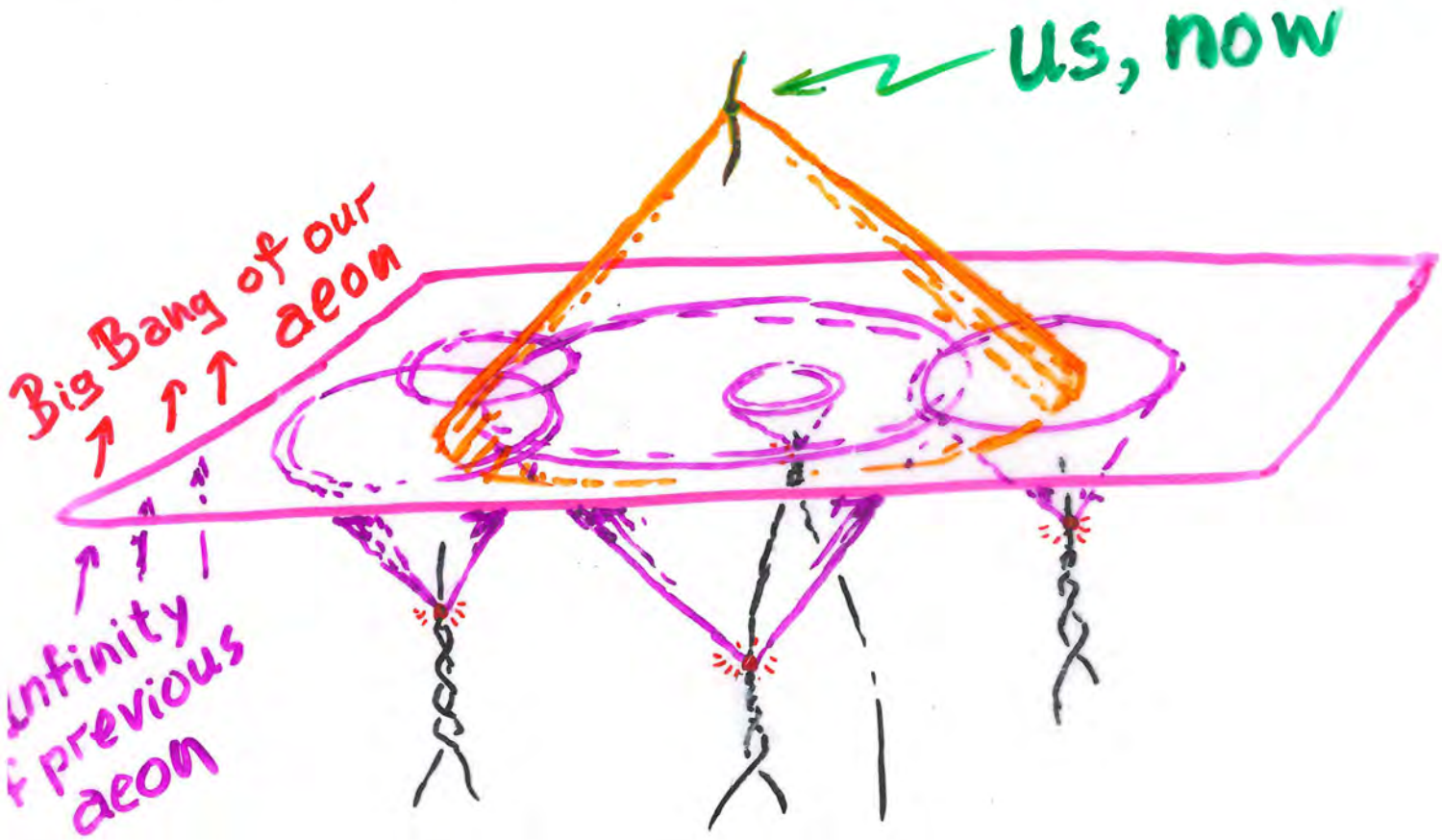


degrees of freedom lost in the black hole





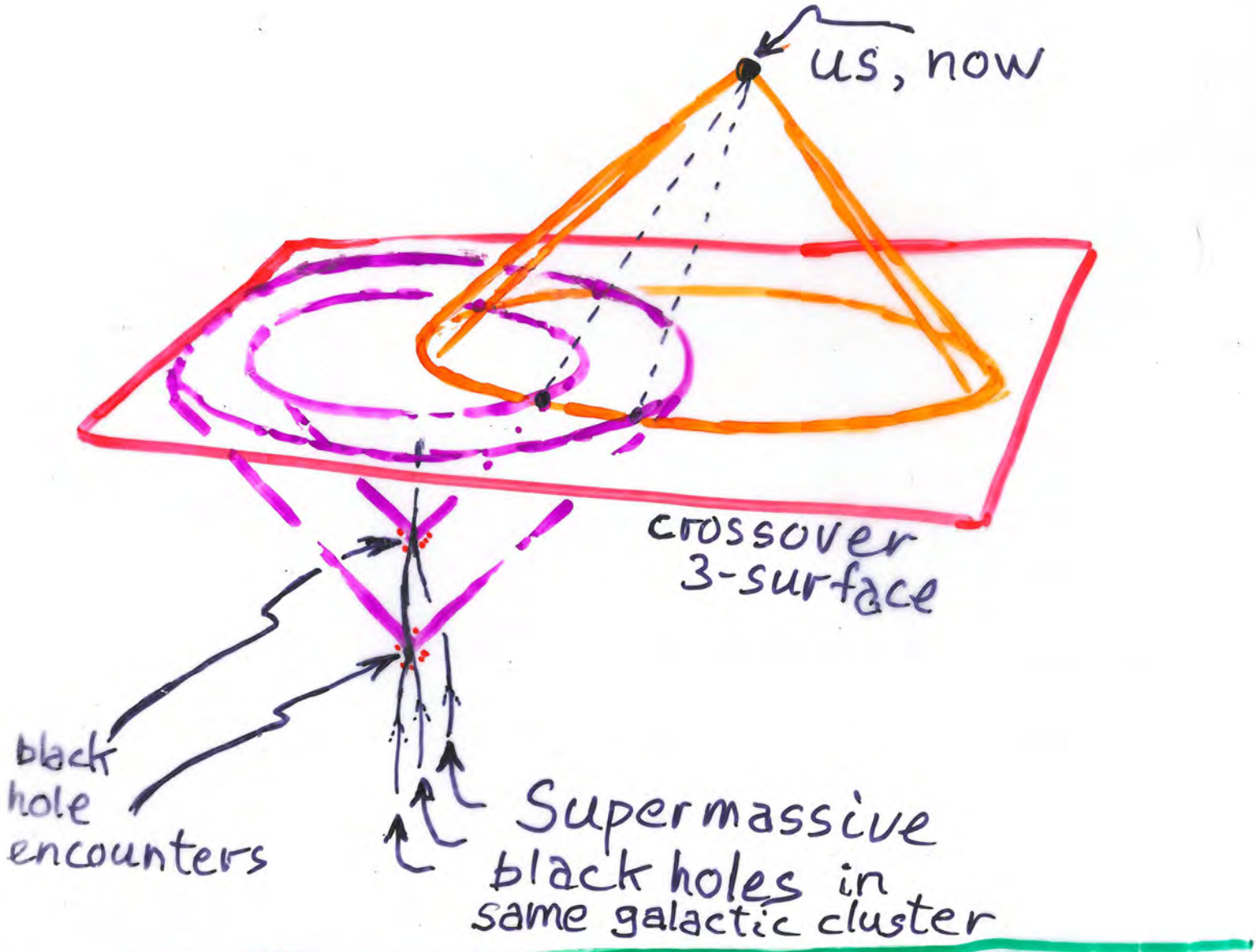
Observational consequence concerning temperature/density variations in Cosmic Microwave Background



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

The Sky-Twist Test

(θ, ϕ) spherical polar angles

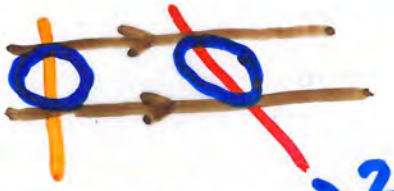
each latitude line rotates by an amount proportional to θ

Area preserving

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

(in degrees)

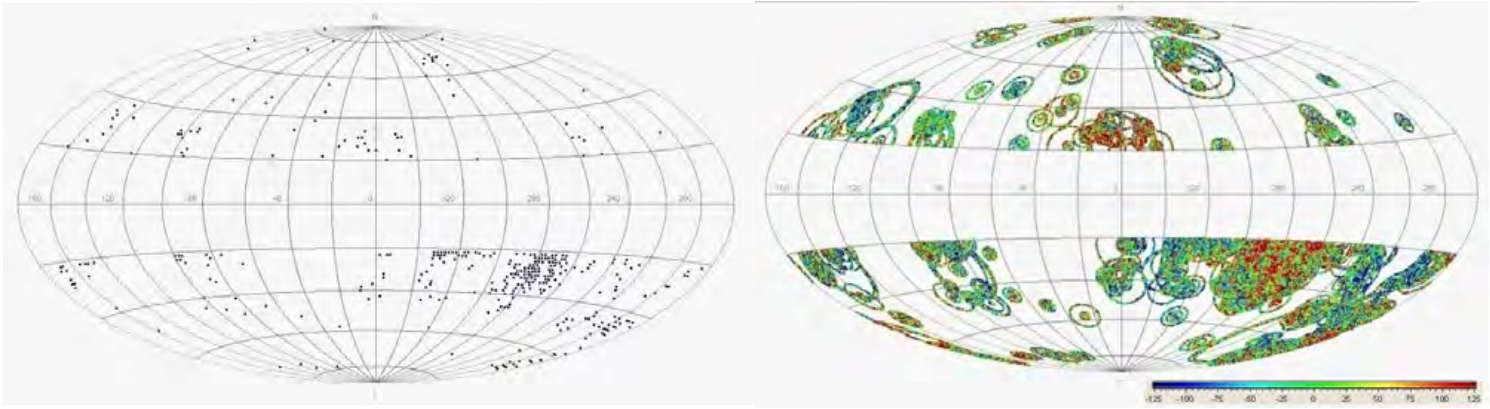
Infinitesimally:



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

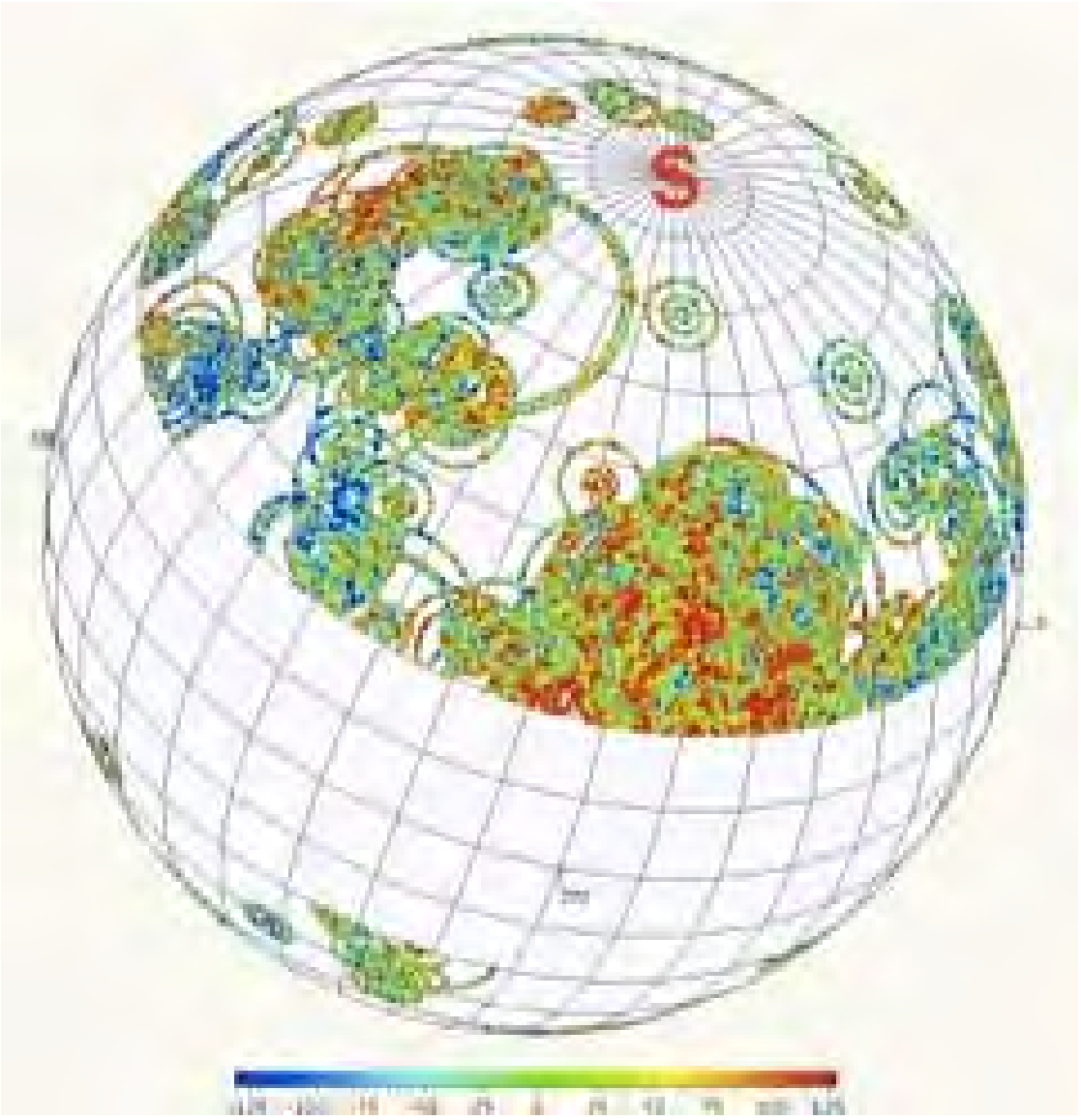
where $s = \frac{1}{180}|S| \sin\theta$

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



$S = 0$, $N = 352$

The sky distribution of concentric sets containing three or more circles of variance depth over 15μK: the left-hand figure indicates the positions of the 352 centres; the right-hand one exhibits the actual circles.


S