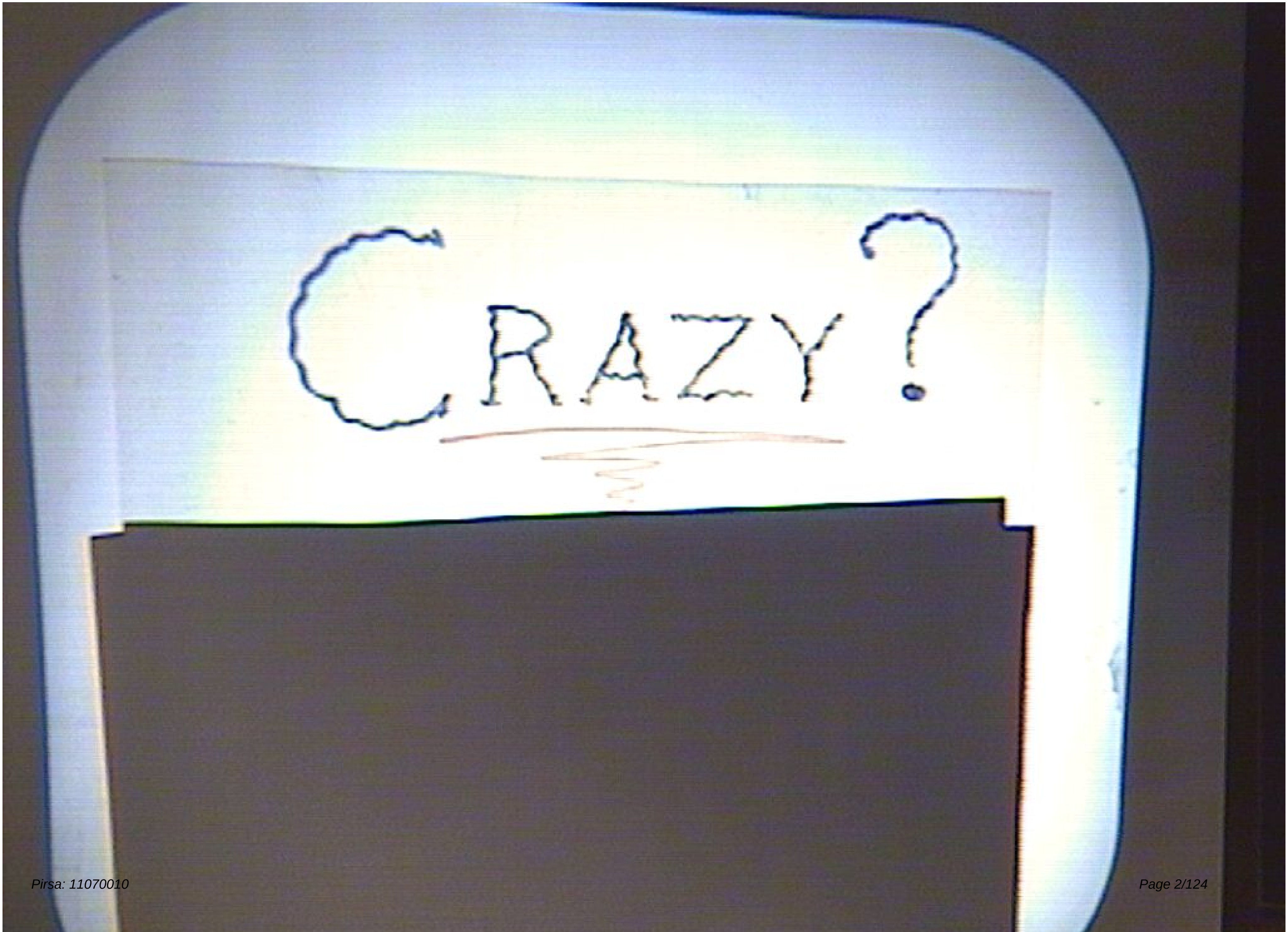
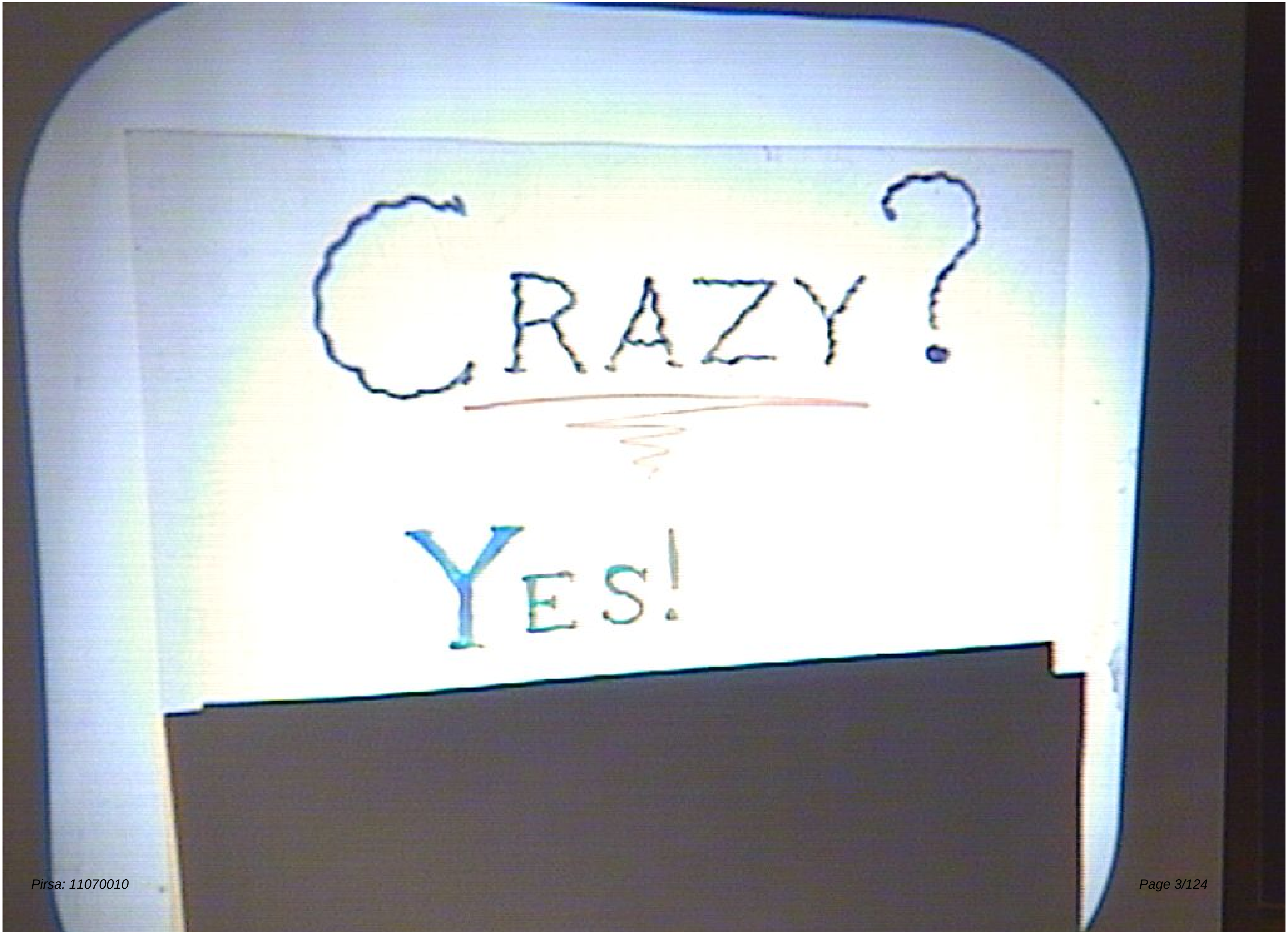
Title: Conformal Cyclic Cosmology: Some Striking New Observational Support

Date: Jul 14, 2011 12:10 PM

URL: http://pirsa.org/11070010

Abstract:


CRAZY?


CRAZY?
YES!

YES!

But it provides new insights into several outstanding problems of cosmology:

- second law of thermodynamics
- "dark energy"
- "dark matter"
- black-hole "information paradox"
- structure of the microwave background
- inflation? x

- No eternal inflation
- No ordinary inflation
- No Boltzmann brains (B-brains)
- No D-branes
- No p-branes
- No strings
- No extra dimensions
- No instantons
- No AdS-CFT
- No quantum gravity

- No symm. bre
- No bubbl
- No tunnelling
- No anthropics
- No landscape

-

- No eternal inflation
- No ordinary inflation
- No Boltzmann brains
  (B-brains)
- No D-branes
- No p-branes
- No strings
- No extra dimensions
- No instantons
- No AdS-CFT
- No quantum gravity
- No symm. breaking
- No bubbles
- No tunnelling
- No anthropics
- No landscape

!

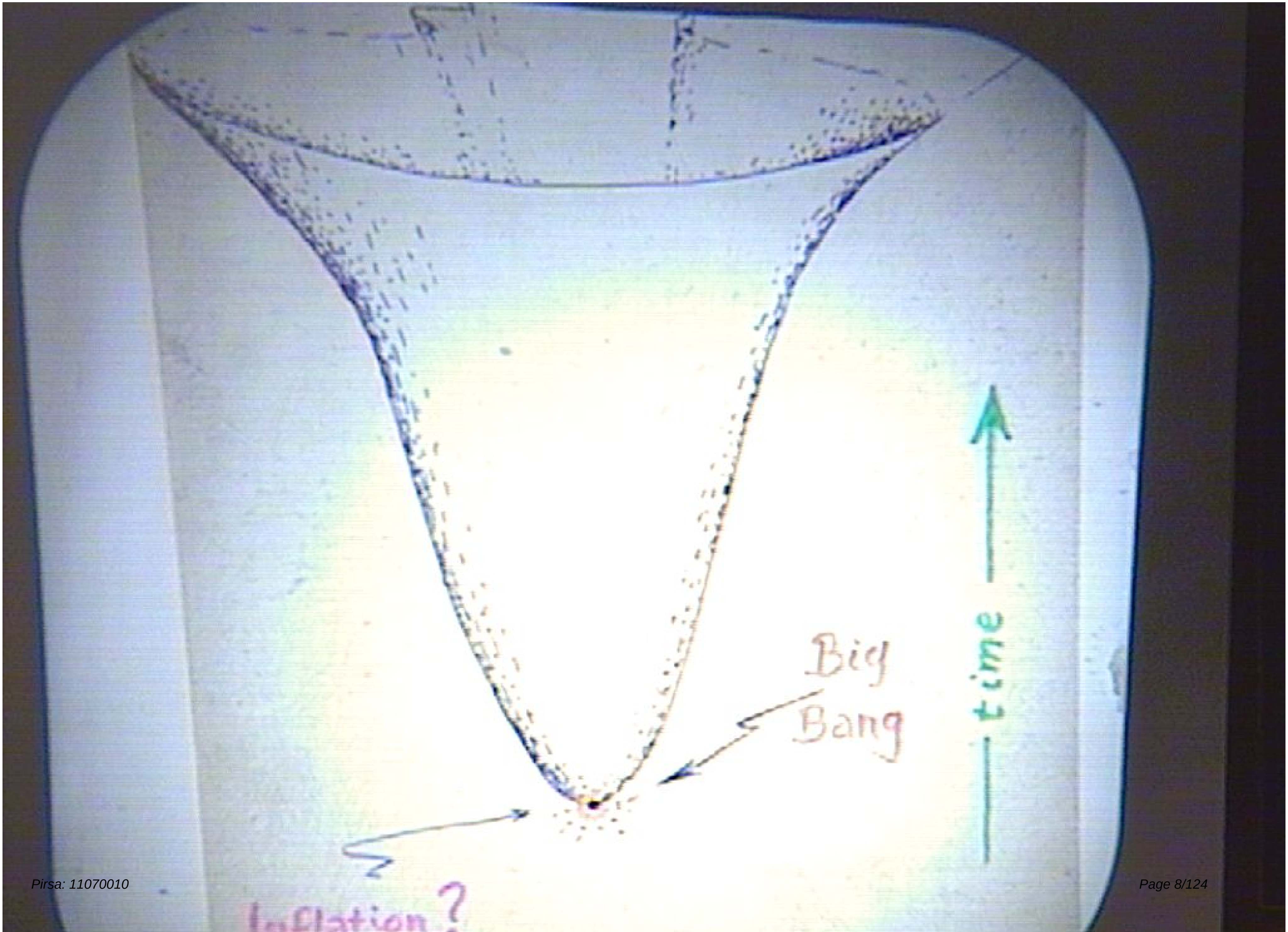
- Only standard classical Einstein Λ (>0)-general relativity
  — with a slight extra twist!

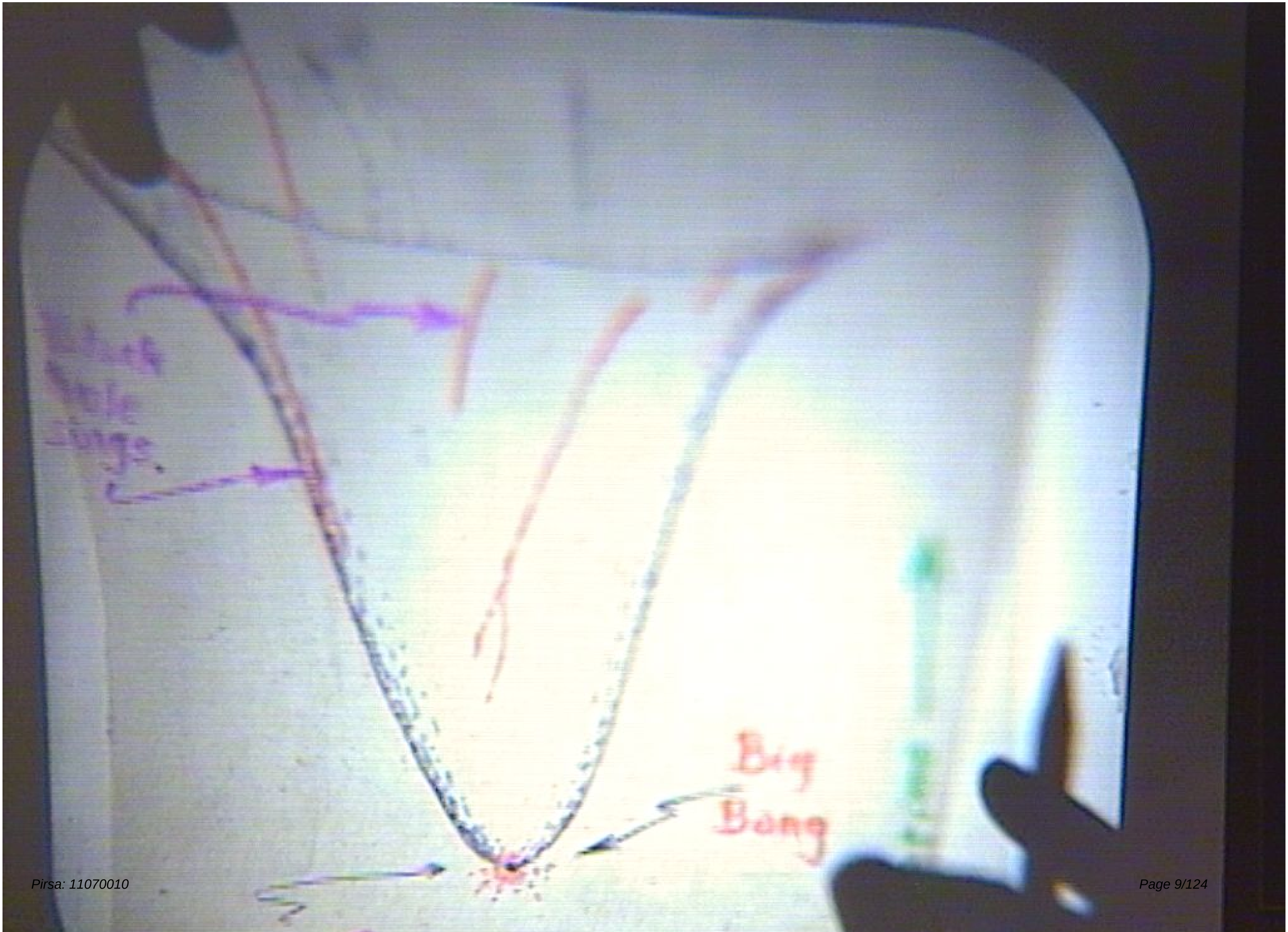
- No eternal inflation
- No ordinary inflation
- No Boltzmann brains (B-brains)
- No D-branes
- No p-branes
- No strings
- No extra dimensions
- No instantons
- No AdS-CFT
- No quantum gravity

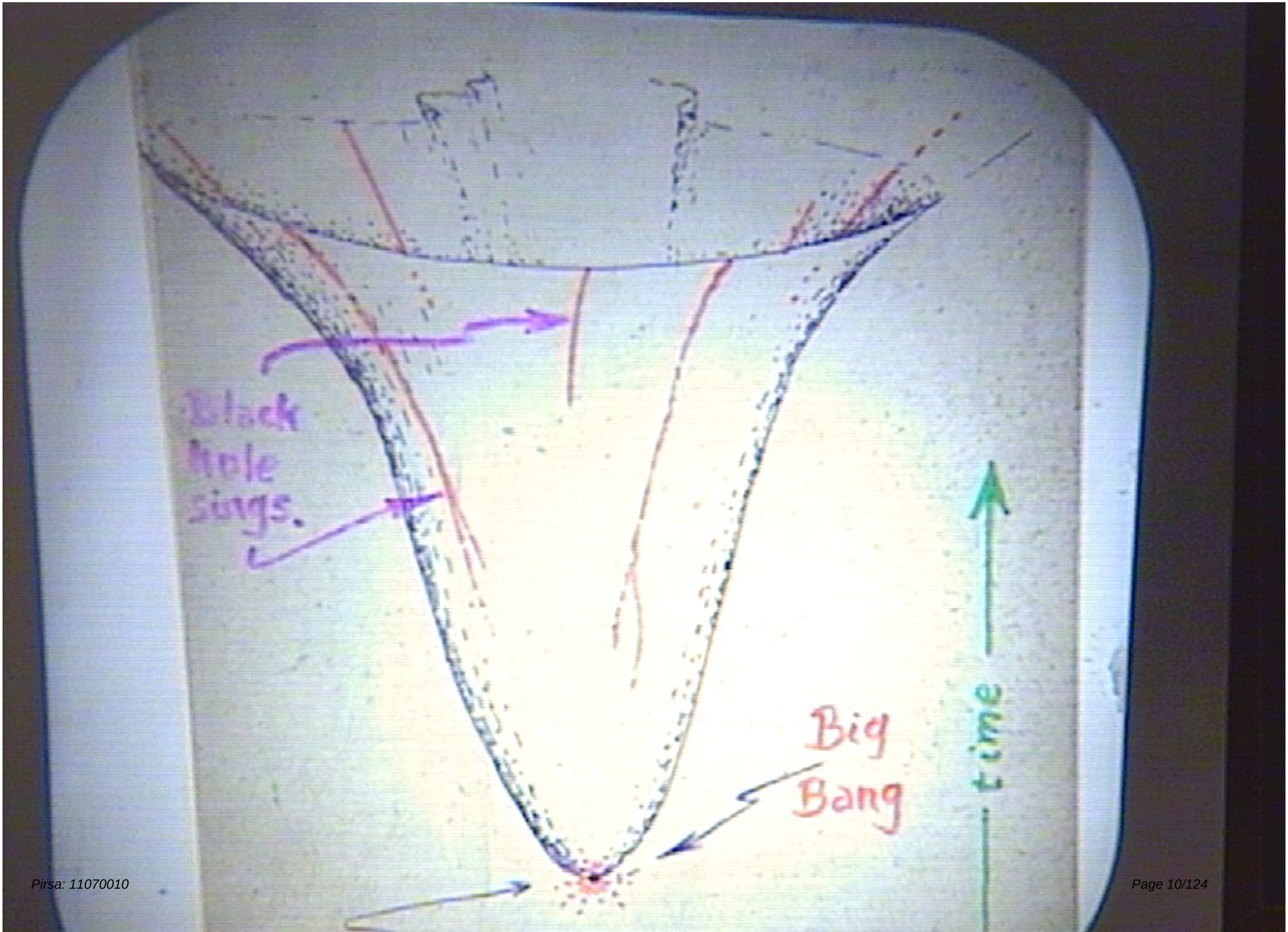
!

- Only standard classical Einstein $\Lambda (>0)$-general relativity
  — with a slight extra twist!

- No twistors


Big
Bang
time
Inflation?


Big
Bang



Black hole sings.
Big Bang
time

Fundamental [illegible]
raised by the 2nd law
of thermodynamics &
the nature of the
Big Bang:

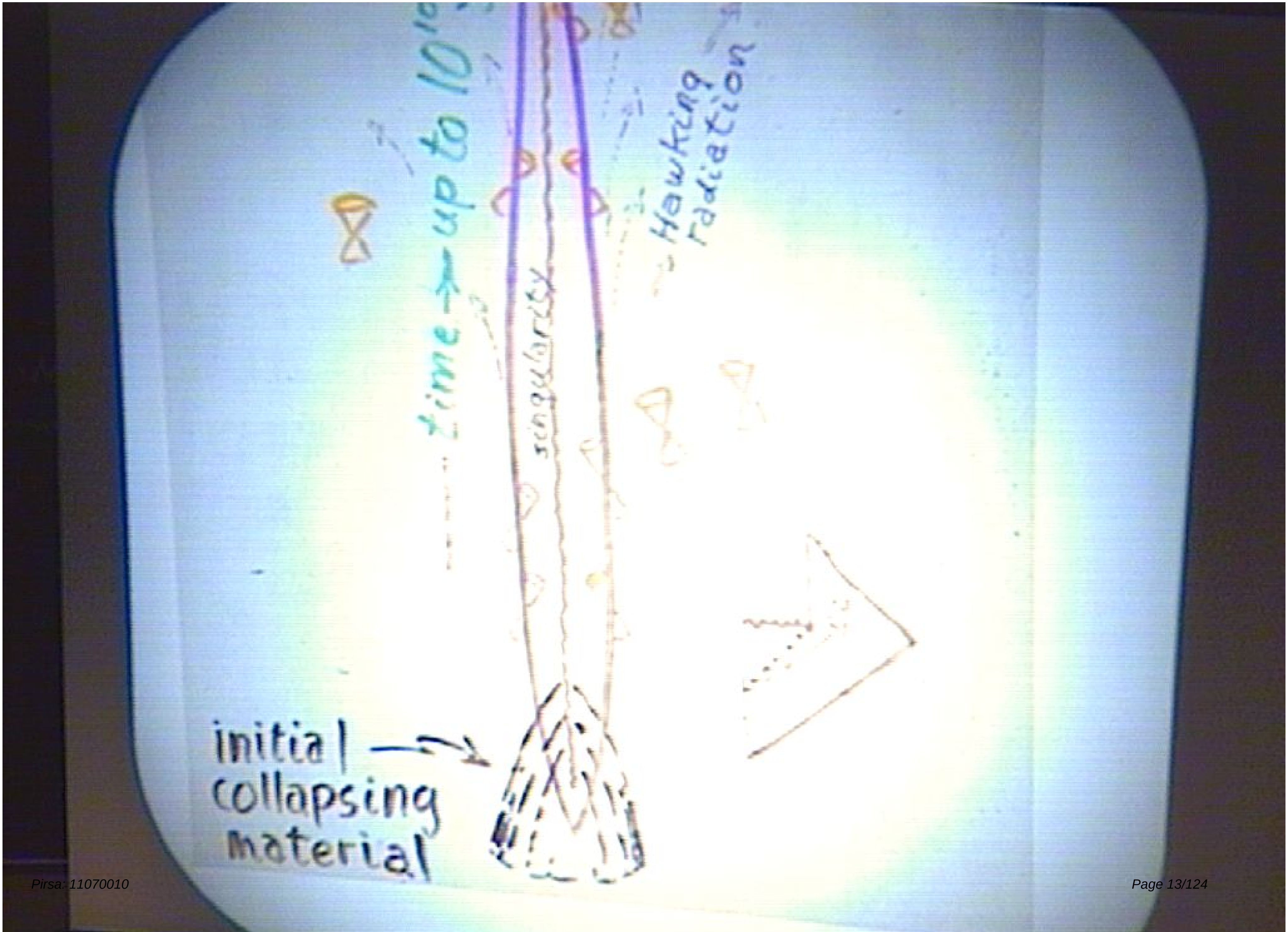
Why did the BB
not involve any white
holes (time-reversed
black holes)?

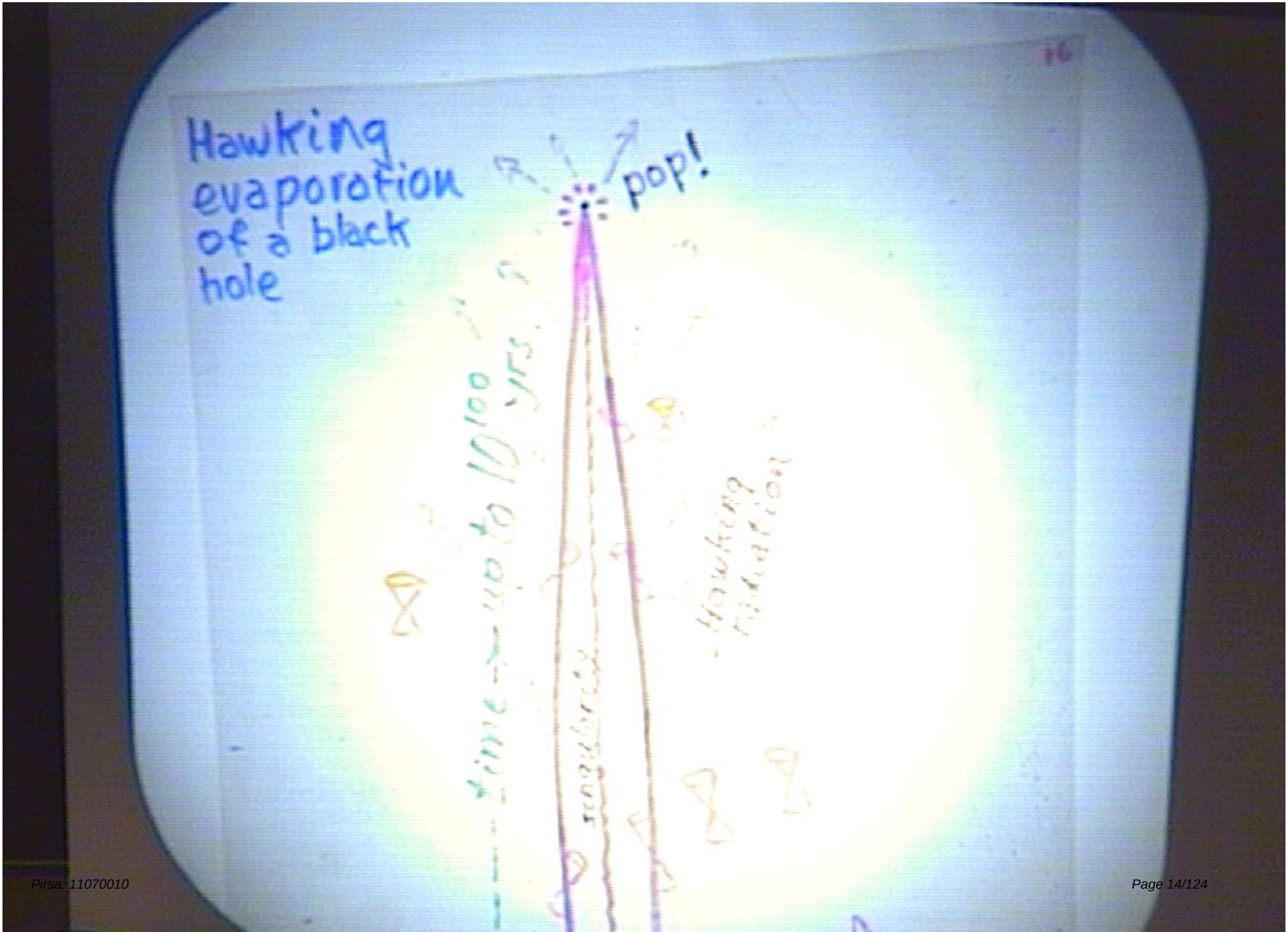
Not answered by
inflation or by any
(current) theory of
quantum

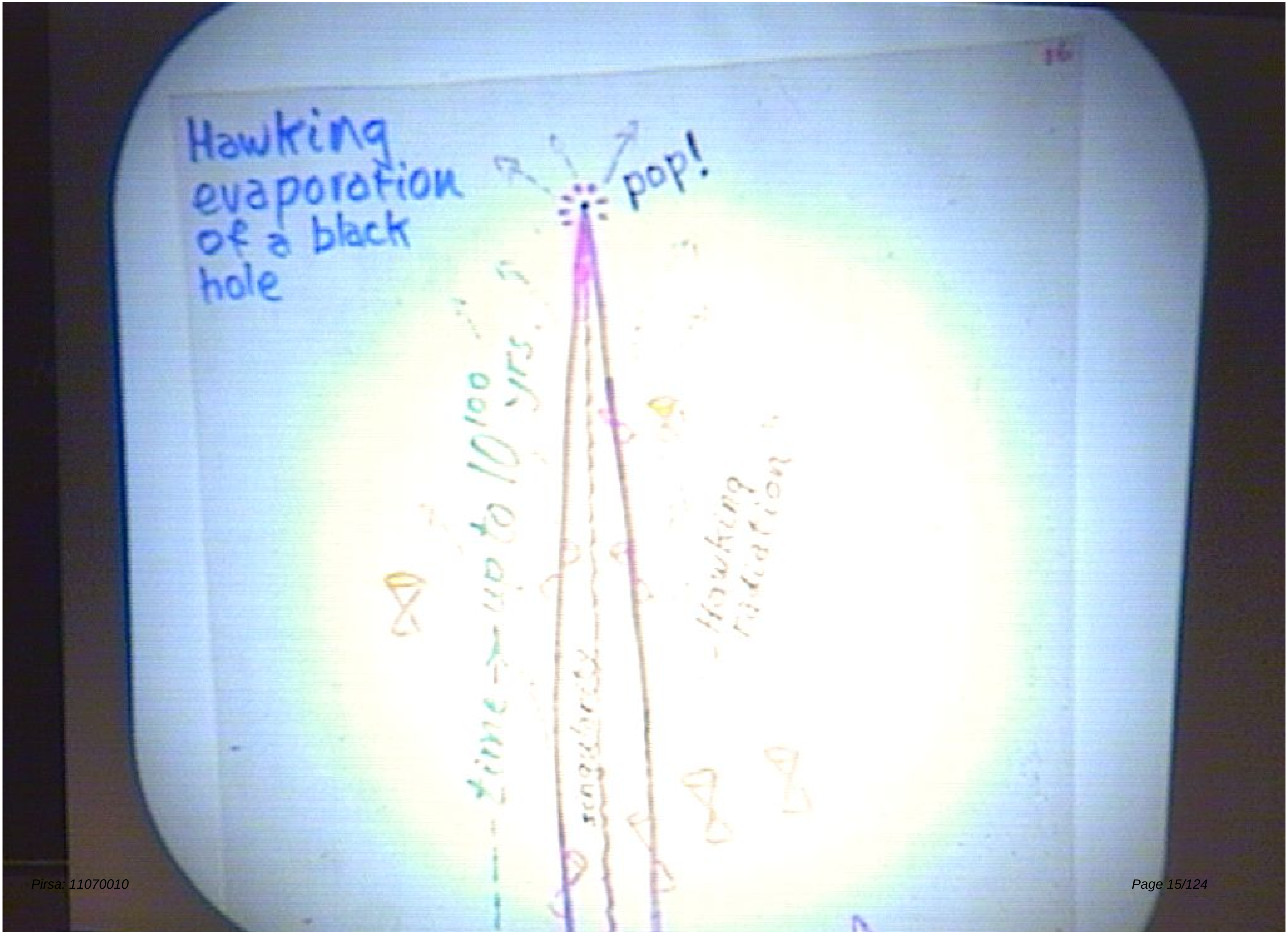
Fundamental pro...
raised by the 2^{nd} law
of thermodynamics &
the nature of the
Big Bang:

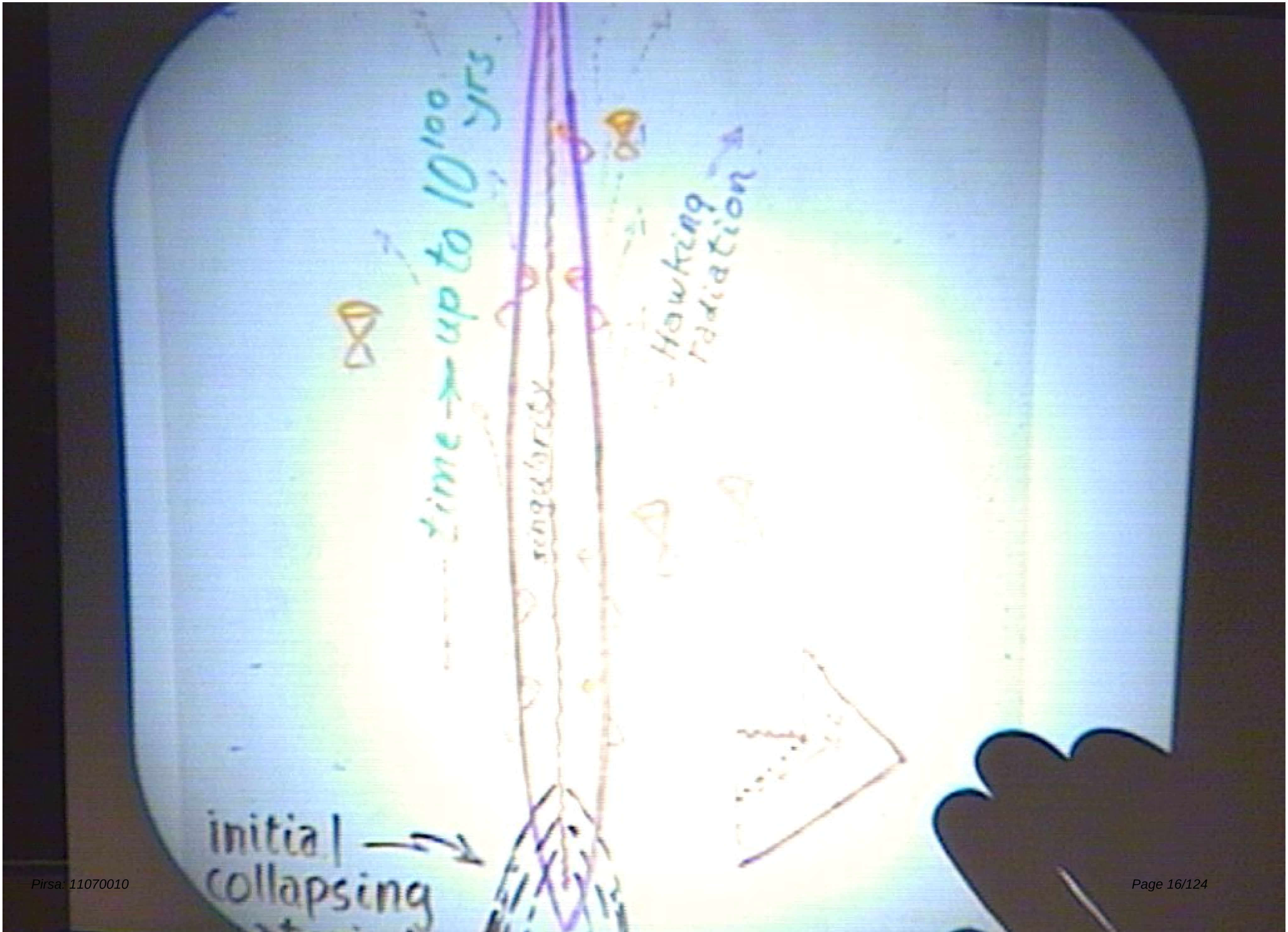
Why did the BB
not involve any white
holes (time-reversed
black holes)?

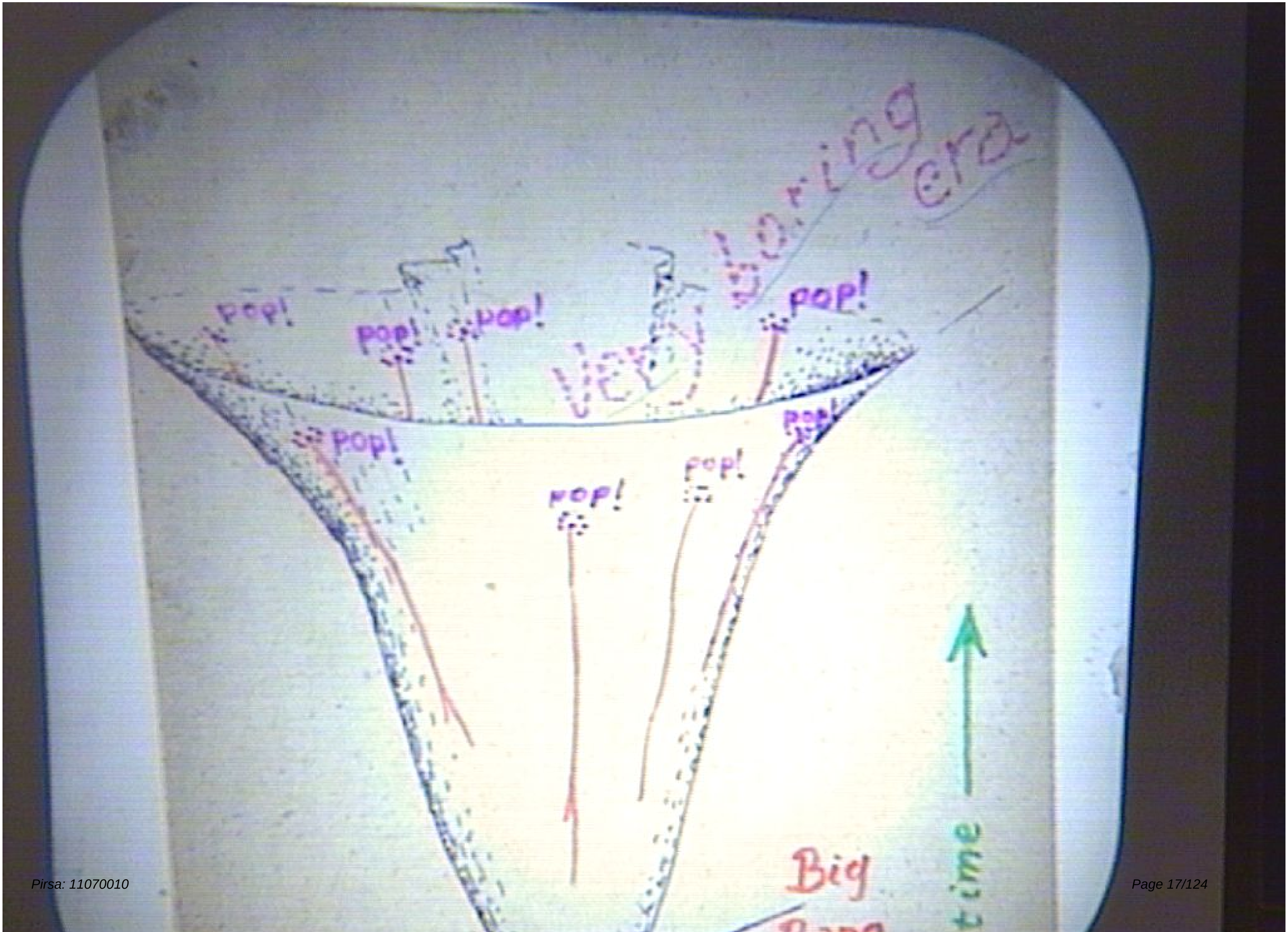
Not answered by
inflation or by any
(current) theory of
quantum...


time → up to 10
singularity
Hawking radiation
initial collapsing material

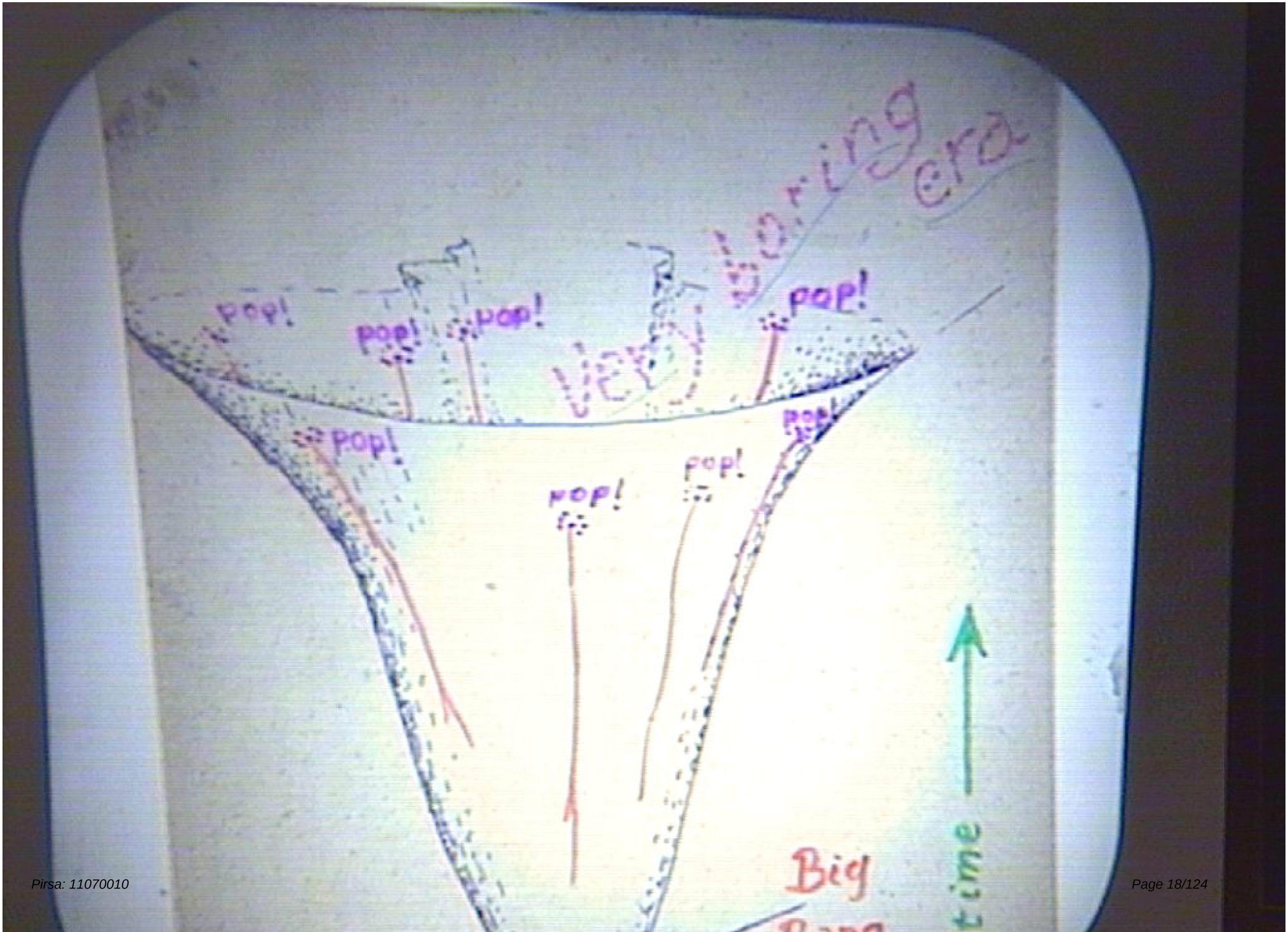

Hawking evaporation of a black hole
pop!
time → up to 10^100 yrs.
singularity
Hawking radiation

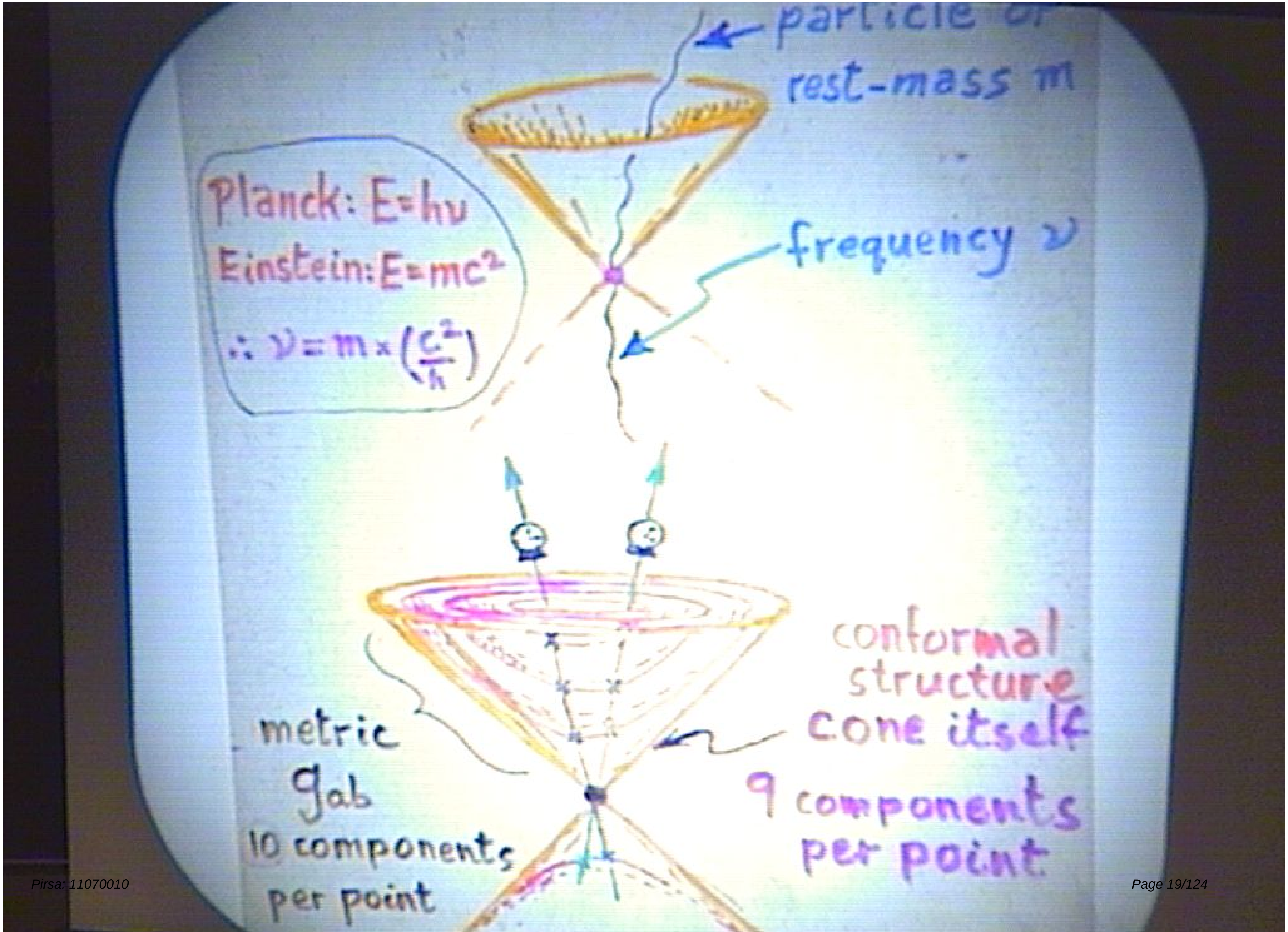

Hawking evaporation of a black hole
pop!
time → up to 10^100 yrs.
singularity
Hawking radiation

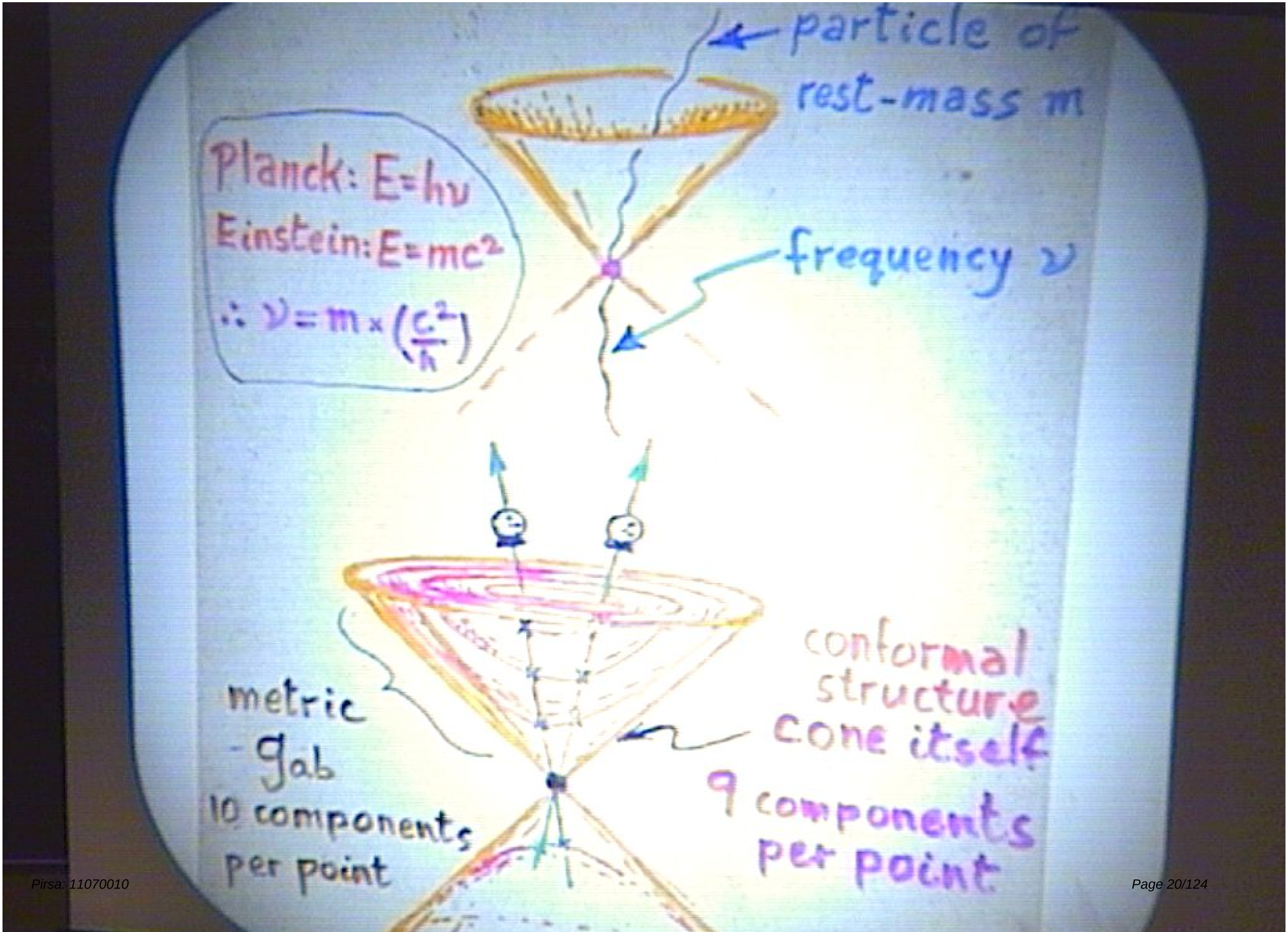

time → up to 10^100 yrs
singularity
Hawking radiation
initial
collapsing

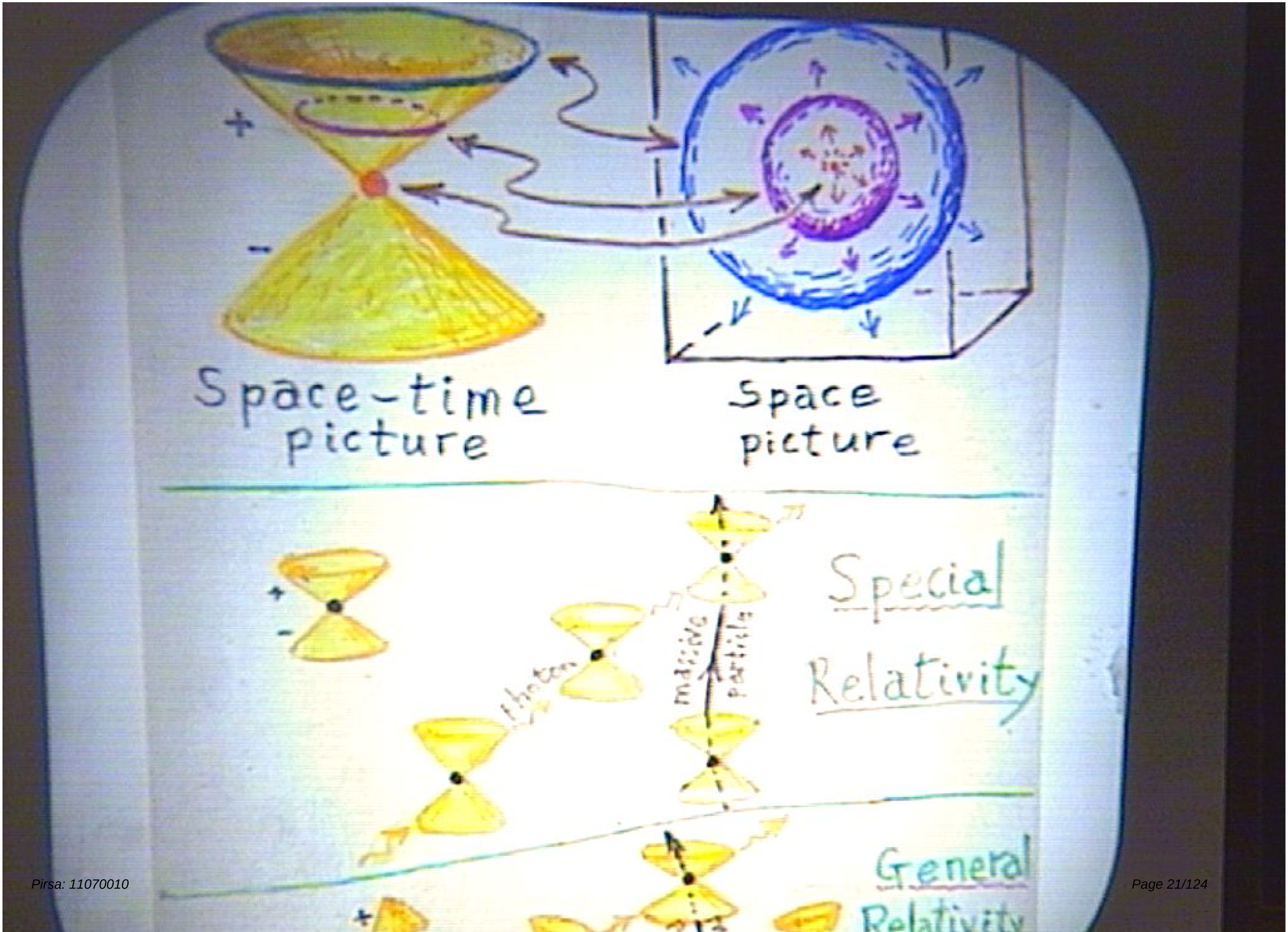


very boring era
pop!
pop!
pop!
pop!
pop!
pop!
pop!
pop!
pop!
Big
time

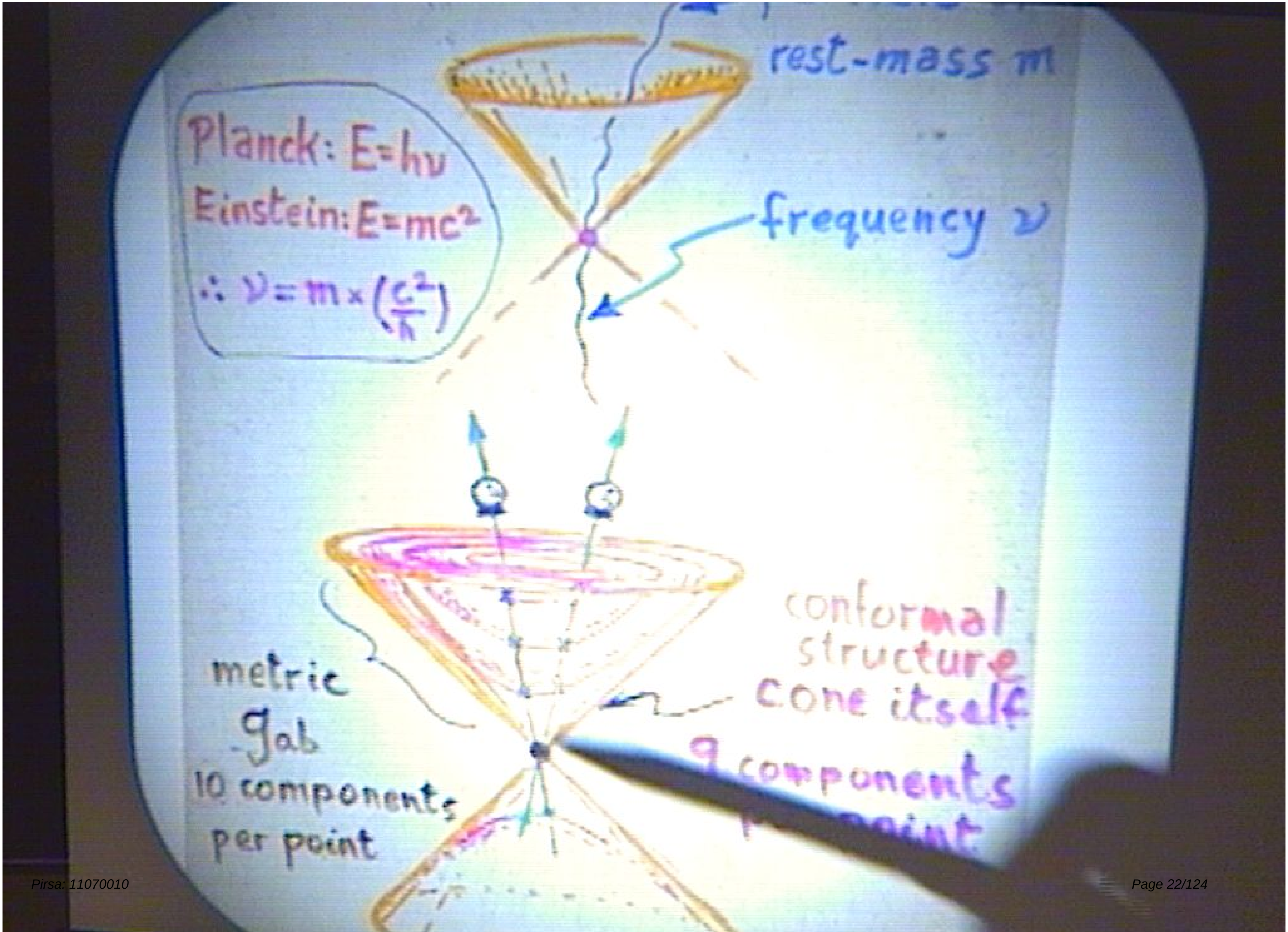

Very boring era
pop!
pop!
pop!
pop!
pop!
pop!
pop!
pop!
pop!
Big
time

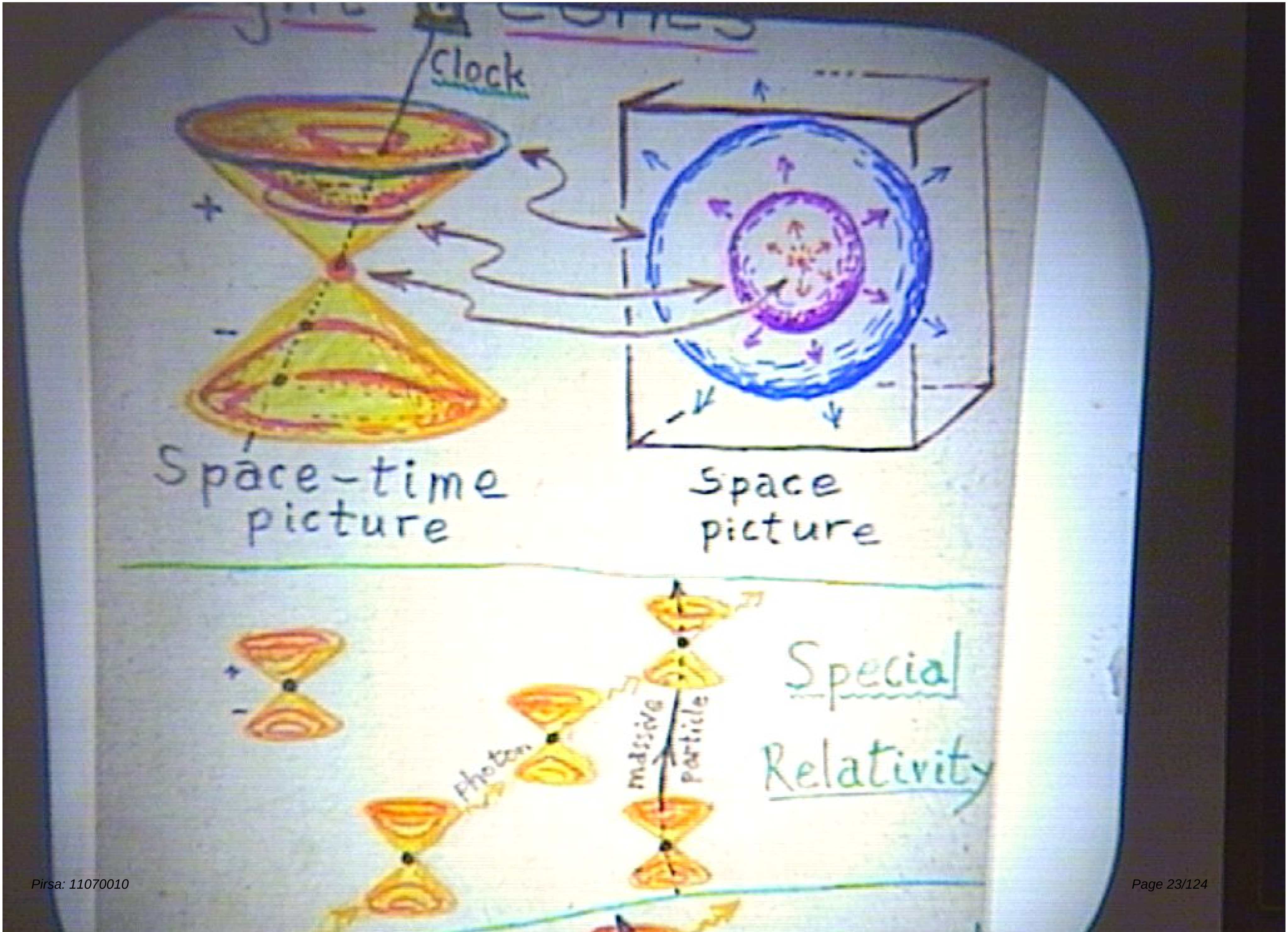

particle of
rest-mass m
Planck: E=hν
Einstein: E=mc²
∴ ν = m × (c²/h)
frequency ν
conformal
structure
cone itself
9 components
per point
metric
g_ab
10 components
per point

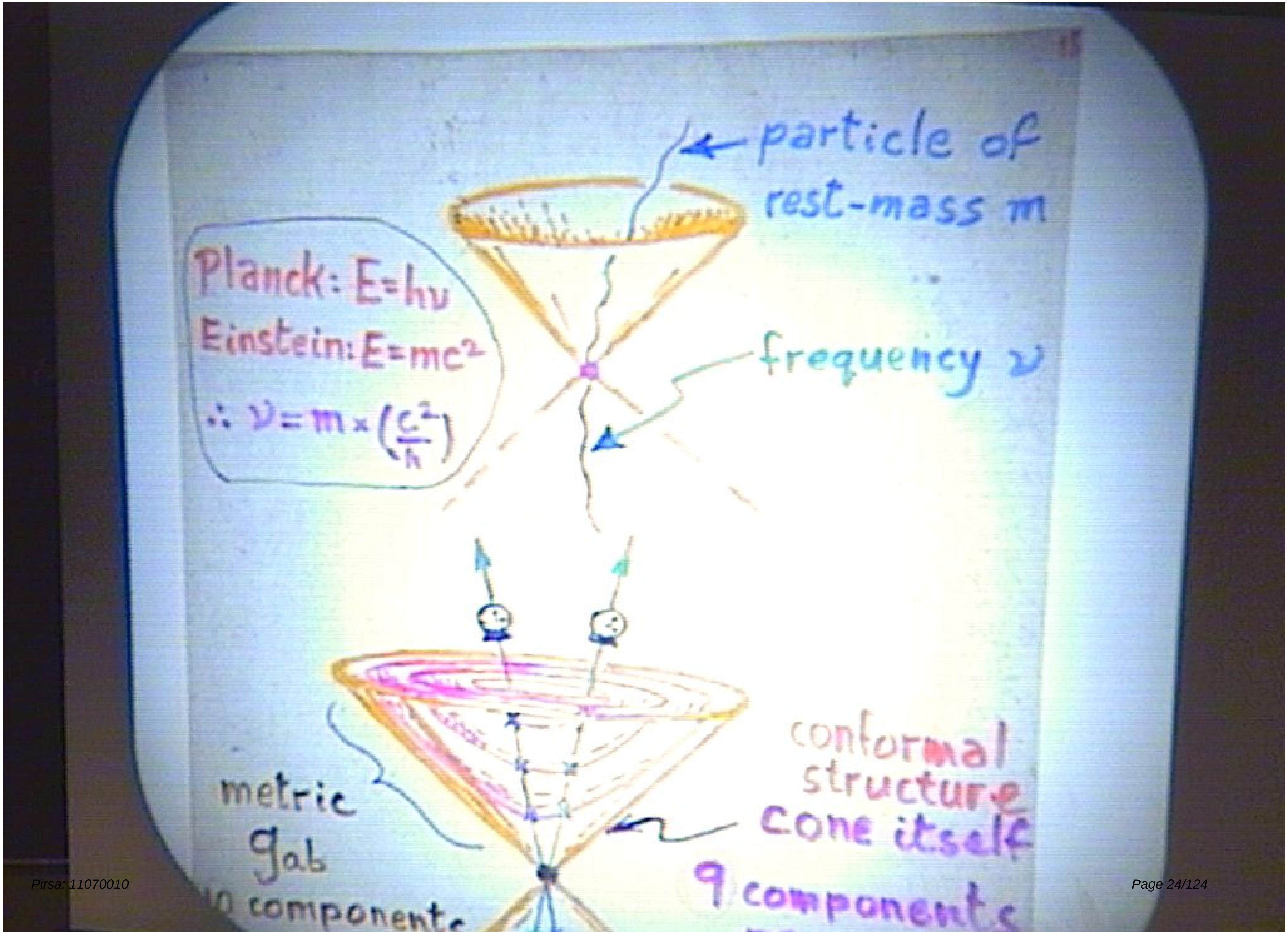

particle of
rest-mass m
Planck: E=hν
Einstein: E=mc²
∴ ν=m×(c²/h)
frequency ν
conformal
structure
cone itself
9 components
per point
metric
g_{ab}
10 components
per point

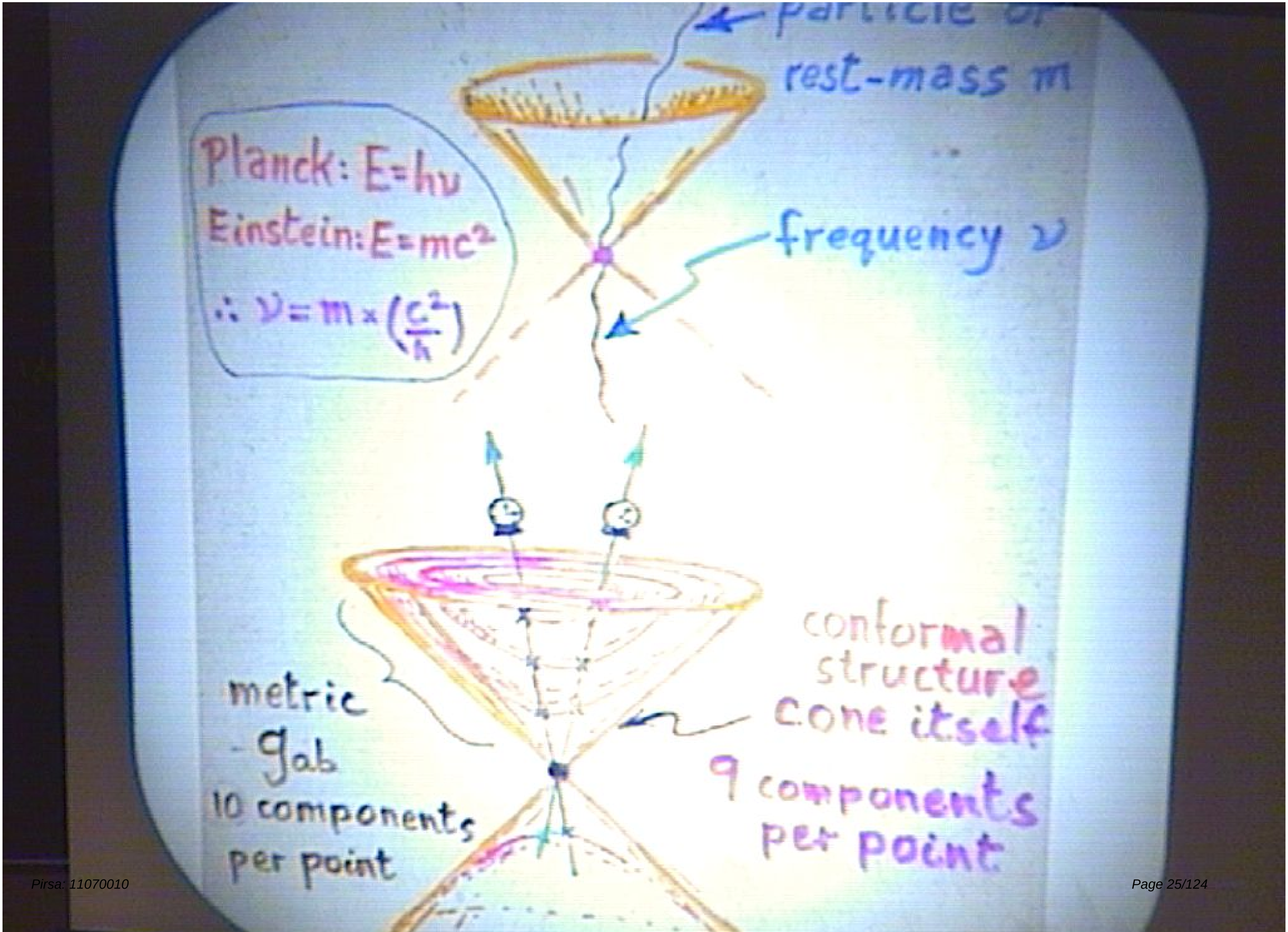


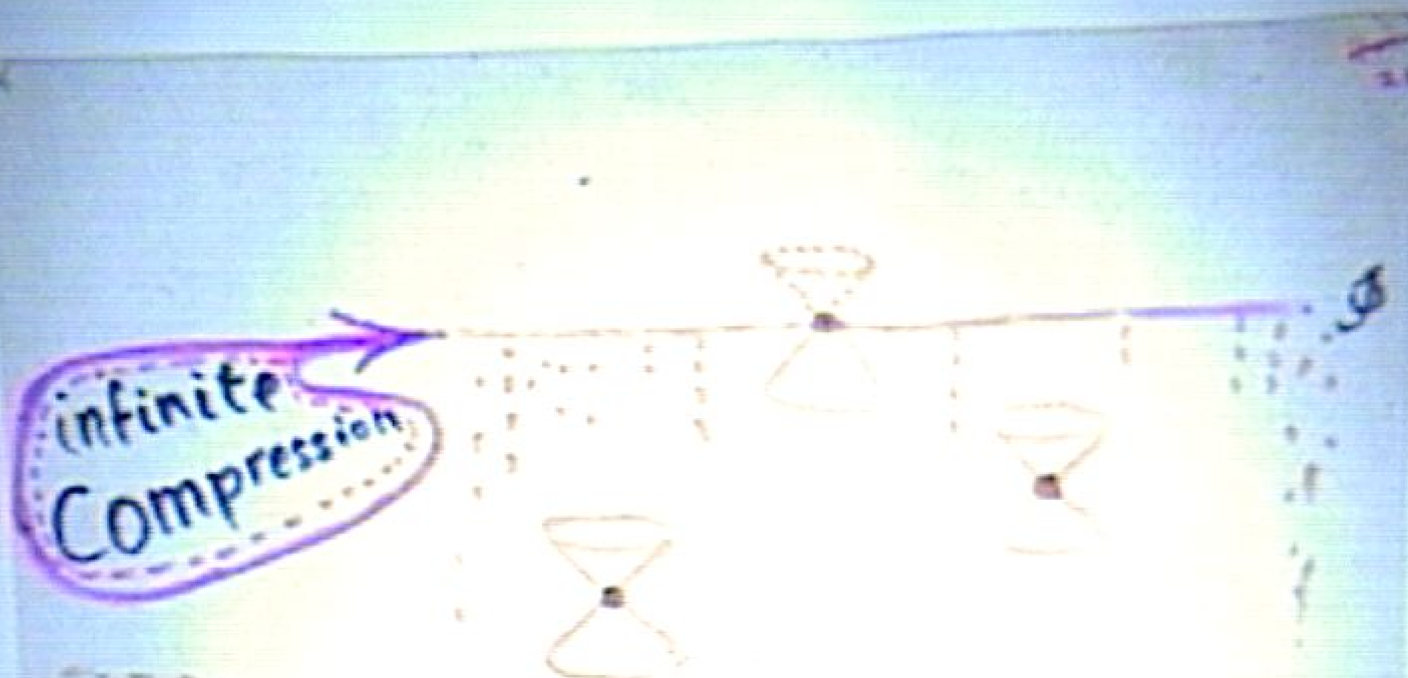
+
-
Space-time
picture
Space
picture
Special
Relativity
photon
massive
particle
General
Relativity


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


Clock
+
-
Space-time picture
Space picture
Special Relativity
photon
massive particle

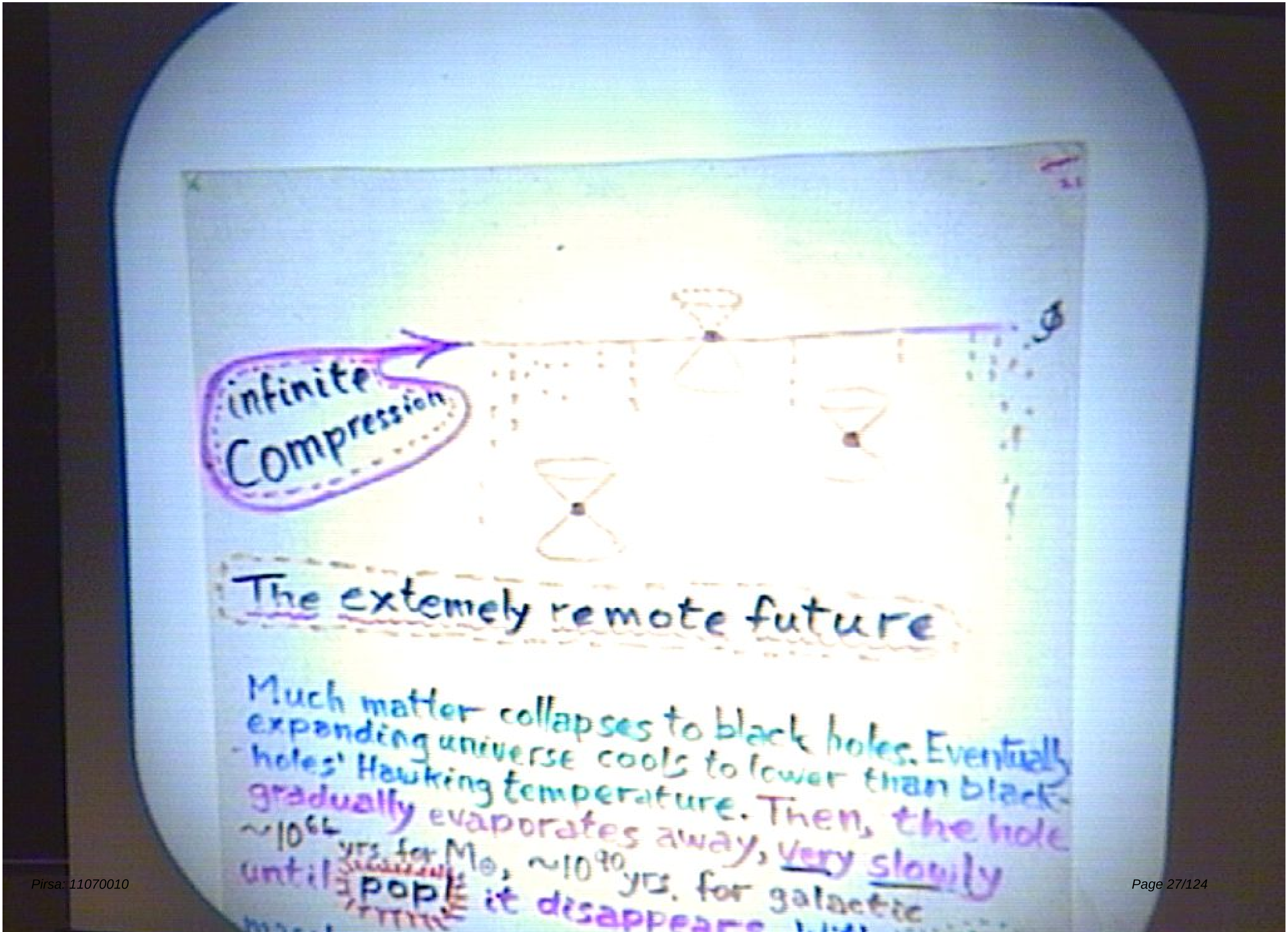

particle of rest-mass m
Planck: E=hν
Einstein: E=mc²
∴ ν=m×(c²/h)
frequency ν
conformal structure
cone itself
9 components
metric
gab
10 components

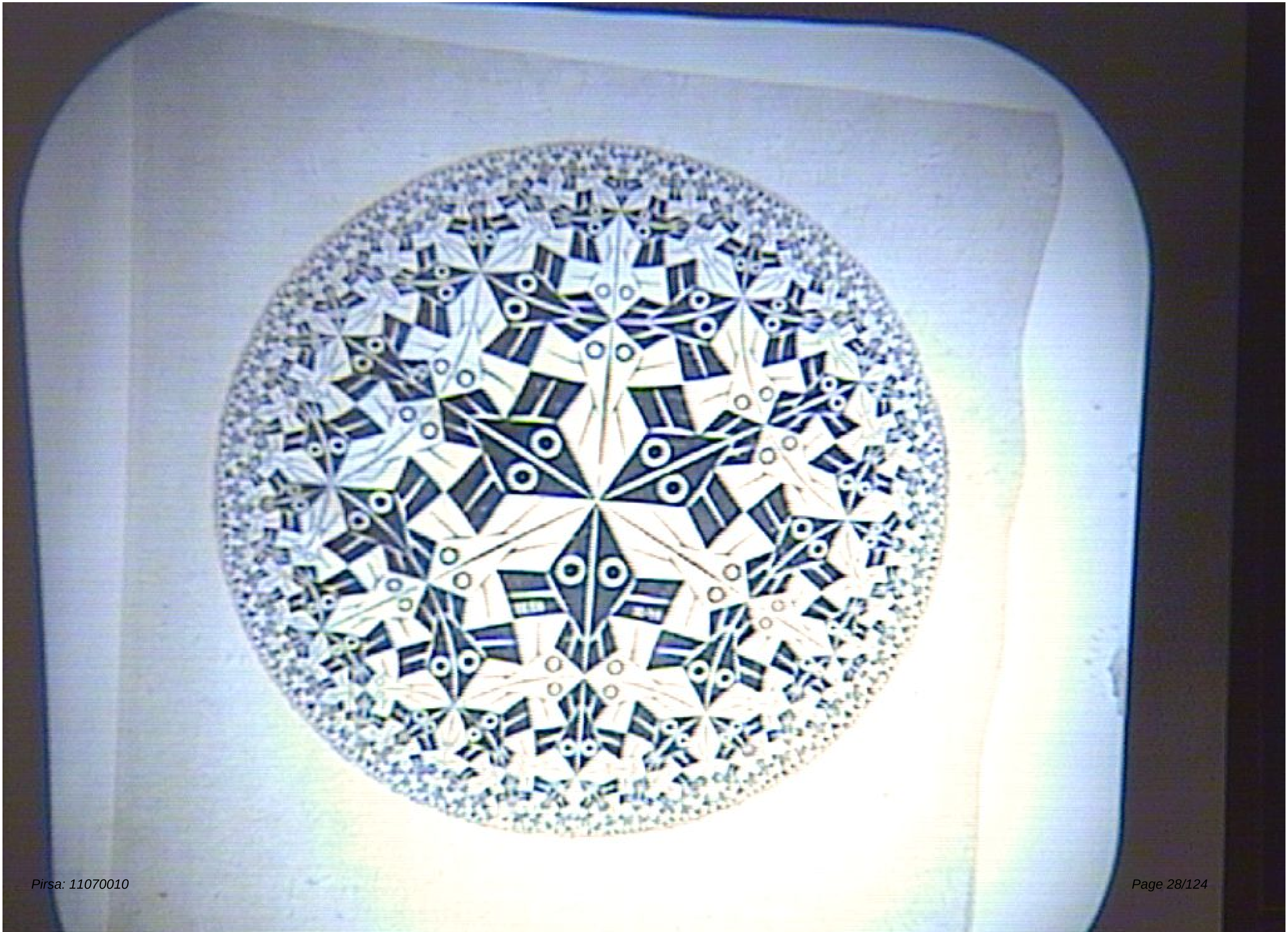

particle of
rest-mass m
Planck: E=hν
Einstein: E=mc²
∴ ν=m×(c²/h)
frequency ν
conformal
structure
cone itself
9 components
per point
metric
g_{ab}
10 components
per point



The extemely remote future

Much matter collapses to black holes. Eventually
expanding universe cools to lower than black-
holes' Hawking temperature. Then, the hole
gradually evaporates away, very slowly
$\sim 10^{64}$ yrs for $M_\odot$, $\sim 10^{90}$ yrs. for galactic
until pop! it disappears. With


infinite Compression
The extemely remote future
Much matter collapses to black holes. Eventually
expanding universe cools to lower than black-
holes' Hawking temperature. Then, the hole
gradually evaporates away, very slowly
~10^64 yrs. for M⊙, ~10^90 yrs. for galactic
until pop! it disappears.



Comp

The extemely remote future

Much matter collapses to black holes. Eventually expanding universe cools to lower than black-holes' Hawking temperature. Then, the hole gradually evaporates away, very slowly $\sim 10^{64}$ yrs. for $M_{\odot}$, $\sim 10^{90}$ yrs. for galactic until **pop!** it disappears. With only massless ingredients left, the universe loses track of time. No way to build a clock!

Eternity is no time at all, for a photon!

0 time

Conformal geometry

Conformal ∞ ($\mathscr{J}$) is spacelike if $\Lambda > 0$. Mathematical

gue electrons?

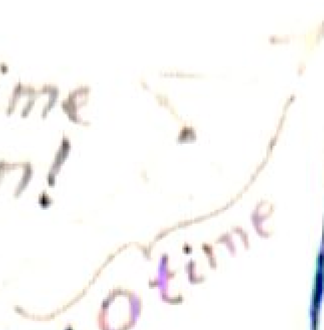
ss evaporation?

extemely remote future

Much matter collapses to black holes. Eventually
expanding universe cools to lower than black-
holes' Hawking temperature. Then, the hole
gradually evaporates away, very slowly
$\sim 10^{64}$ yrs for $M_\odot$, $\sim 10^{90}$ yrs. for galactic
until **pop!** it disappears. With only
massless ingredients left, the universe
loses track of time. No way to
build a clock!

Eternity is no time
at all, for a photon!

Conformal geometry



Conformal ∞ ($\mathscr{I}$) is spacelike
if $\Lambda > 0$. Mathematical trick!

rogue electrons?
mass evaporation?

The extemely remote future

Much matter collapses to black holes. Eventually expanding universe cools to lower than black-holes' Hawking temperature. Then, the hole gradually evaporates away, very slowly until POP! it disappears. $\sim 10^{64}$ yrs for $M_\odot$, $\sim 10^{90}$ yrs. for galactic. With only massless ingredients left, the universe loses track of time. No way to build a clock!

Compression

The extemely remote future

Much matter collapses to black holes. Eventually expanding universe cools to lower than black-holes' Hawking temperature. Then, the hole gradually evaporates away, very slowly $\sim 10^{64}$ yrs. for $M_\odot$, $\sim 10^{90}$ yrs. for galactic until pop! it disappears. With only massless ingredients left, the universe loses track of time. No way to build a clock!

gue electrons?

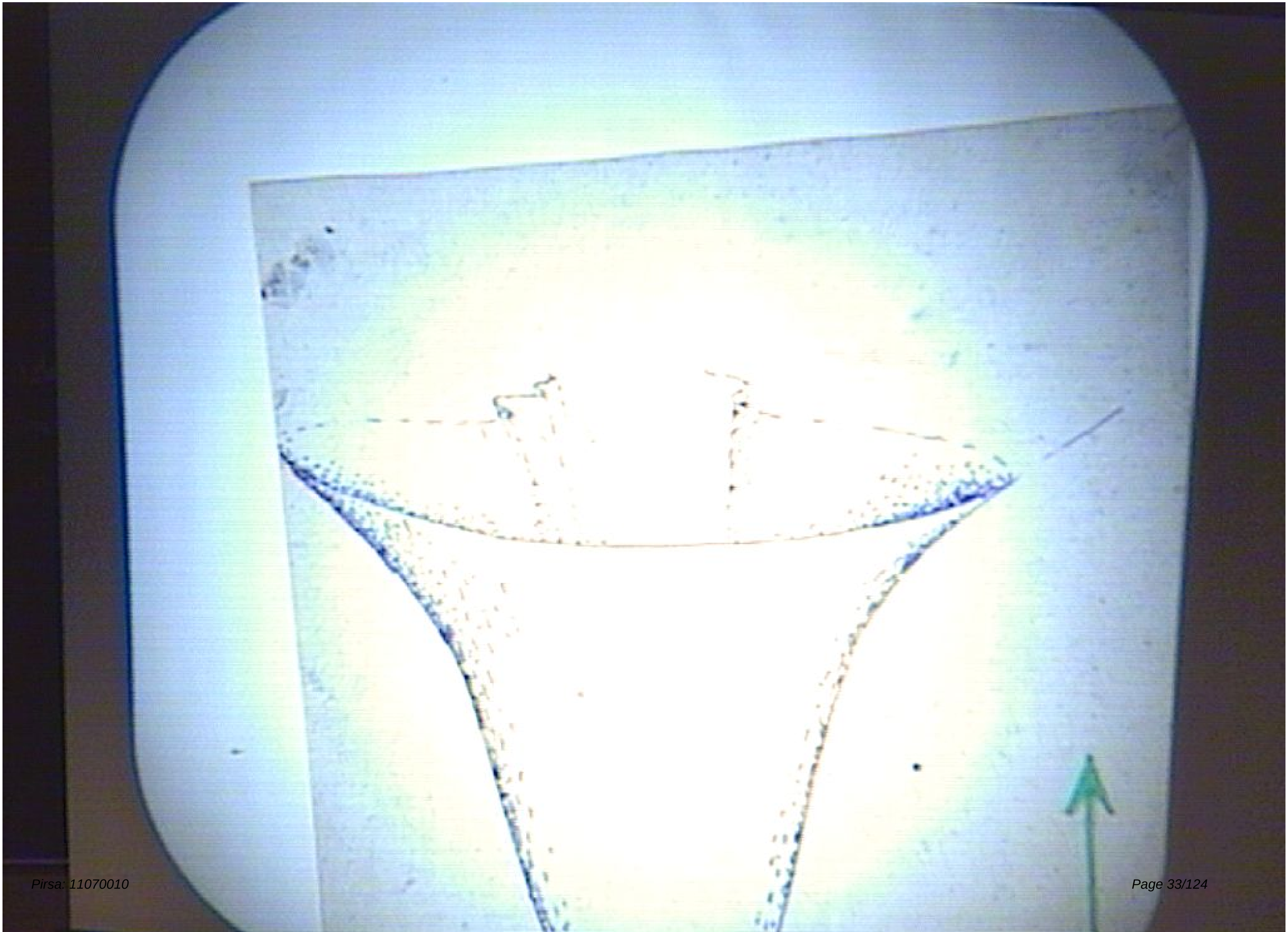
ss evaporation?

Eternity is no time at all, for a photon!

0 time

Conformal geometry

Conformal ∞ ($\mathscr{J}$) is spacelike



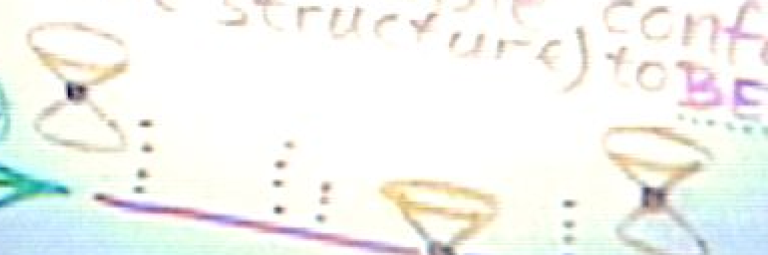
Weyl Curvature Hypothesis

The Big Bang must have been subject to a HUGE constraint — to a region of phase space no larger than 1 part in $10^{10^{124}}$

The specialness in the Big Bang appears to be only in Gravitation i.e. the Weyl curvature appears to have been $= 0$ at the Big Bang Whereas it diverges wildly in black holes

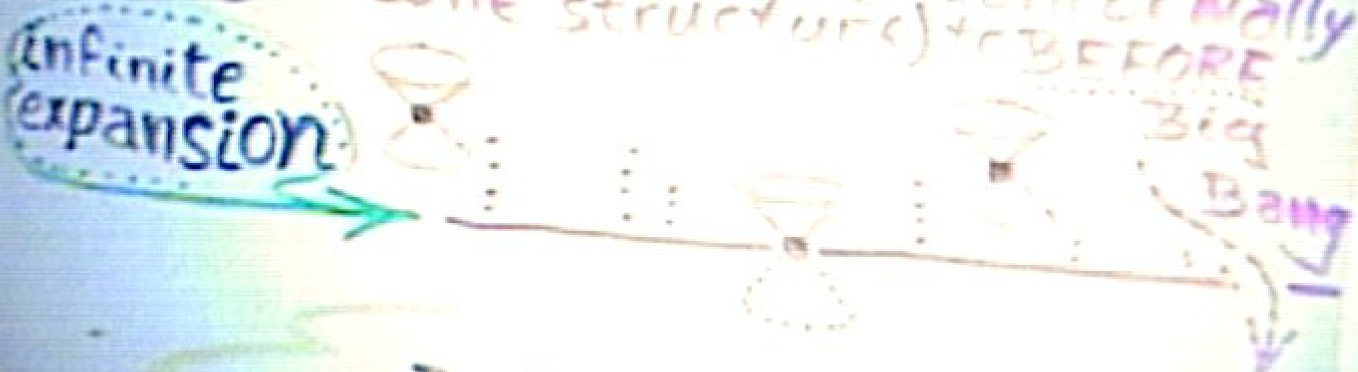
But an awkward condition to state mathematically. Tod's proposal: Space-time extendible conformally (i.e. as light-cone structure) to BEFORE Big Bang

infinite expansion



— to a region of phase space
no larger than 1 part in $10^{10^{124}}$

The specialness in the Big Bang
appears to be only in Gravitation
i.e. the Weyl curvature appears to
have been $= 0$ at the Big Bang
Whereas it diverges wildly in black holes
But an awkward condition to state
mathematically. Tod's proposal:
space-time extendible conformally
(i.e. as light-cone structure) to BEFORE



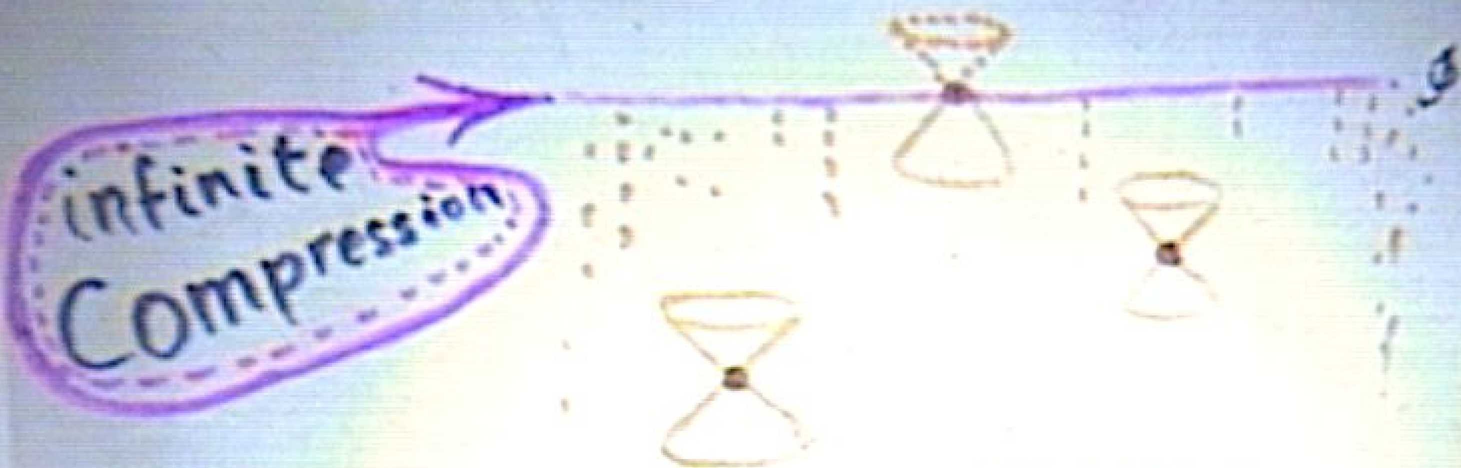
Just a mathematical trick!.....? Temperatures
become so large at the Big B
rest masses become

— to a region of phase space
no larger than $\boxed{1 \text{ part in } 10^{10^{124}}}$

The specialness in the Big Bang
appears to be only in Gravitation
i.e. the Weyl curvature appears to
have been = 0 at the Big Bang
Whereas it diverges wildly in black holes
But an awkward condition to state
mathematically. Tod's proposal:
space-time extendible conformally
(i.e. as light-cone structure) to BEFORE
Big Bang

(infinite expansion)

Just a mathematical
trick! ......? Temperatures
become so large at the Big B
rest masses be



The extemely remote future

Much matter collapses to black holes. Eventually expanding universe cools to lower than black-holes' Hawking temperature. Then, the hole gradually evaporates away, very slowly $\sim 10^{64}$ yrs. for $M_\odot$, $\sim 10^{90}$ yrs. for galactic until POP! it disappears. With only ...ients left, the universe no larger than 1 part in 10

The specialness in the Big Bang appears to be only in Gravitation i.e. the Weyl curvature appears to have been = 0 at the Big Bang Whereas it diverges wildly in black holes

But an awkward condition to state mathematically. Tod's proposal: space-time extendible conformally (i.e. as light-cone structure) to BEFORE Big Bang

Just a mathematical trick!.....?

Temperatures become so large at the Big Bang that rest masses become ignorable.....

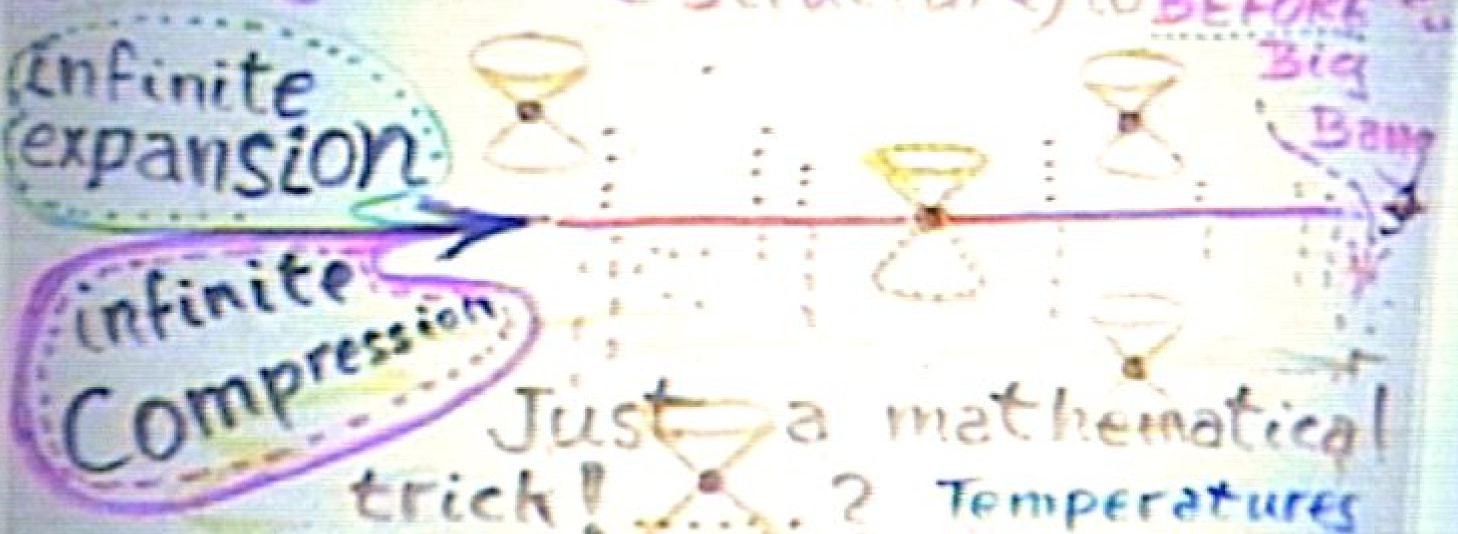
The specialness in the Big Bang appears to be only in Gravitation

i.e. the Weyl curvature appears to have been = 0 at the Big Bang

Whereas it diverges wildly in black holes

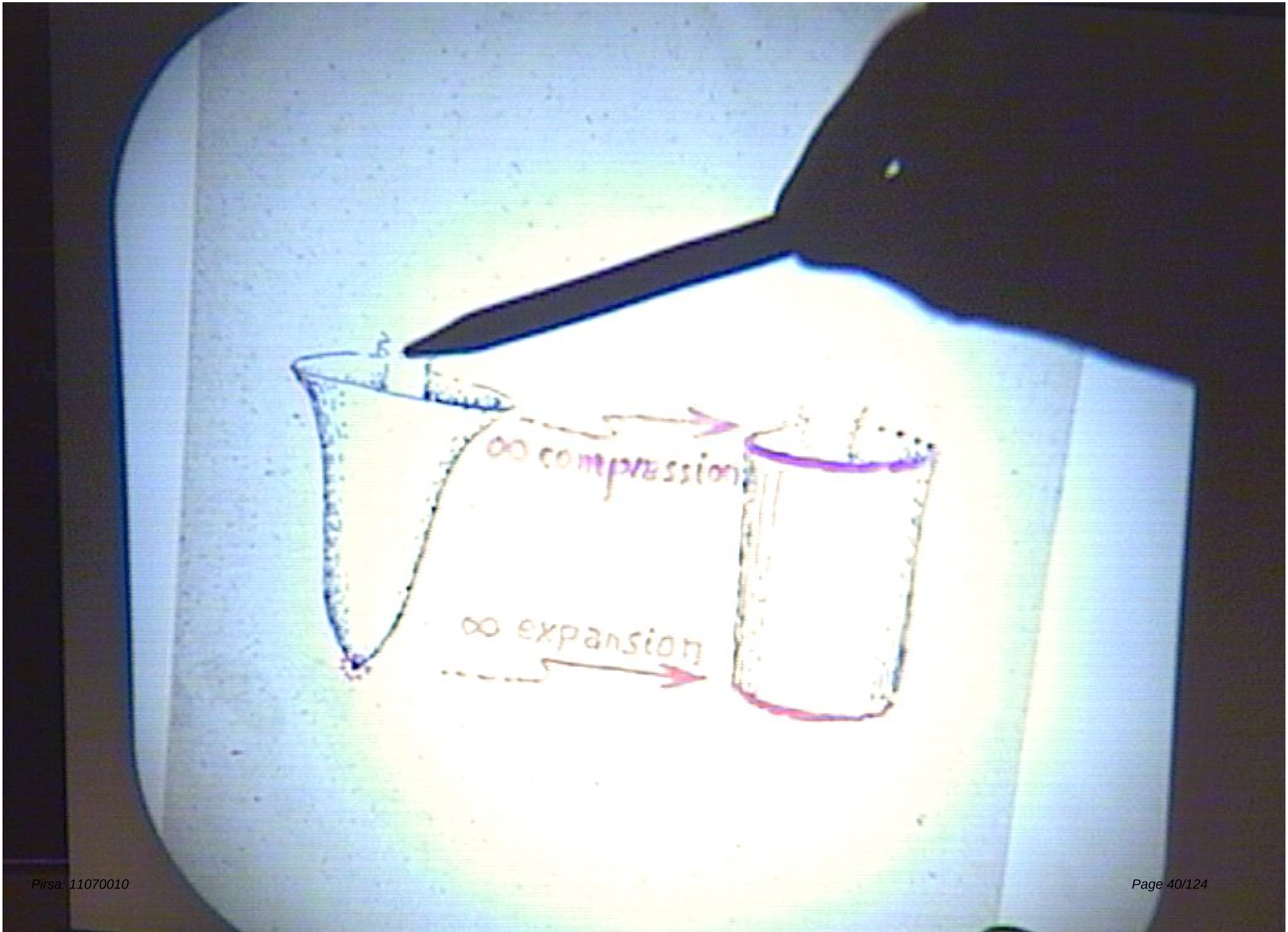
But an awkward condition to state mathematically. Tod's proposal:

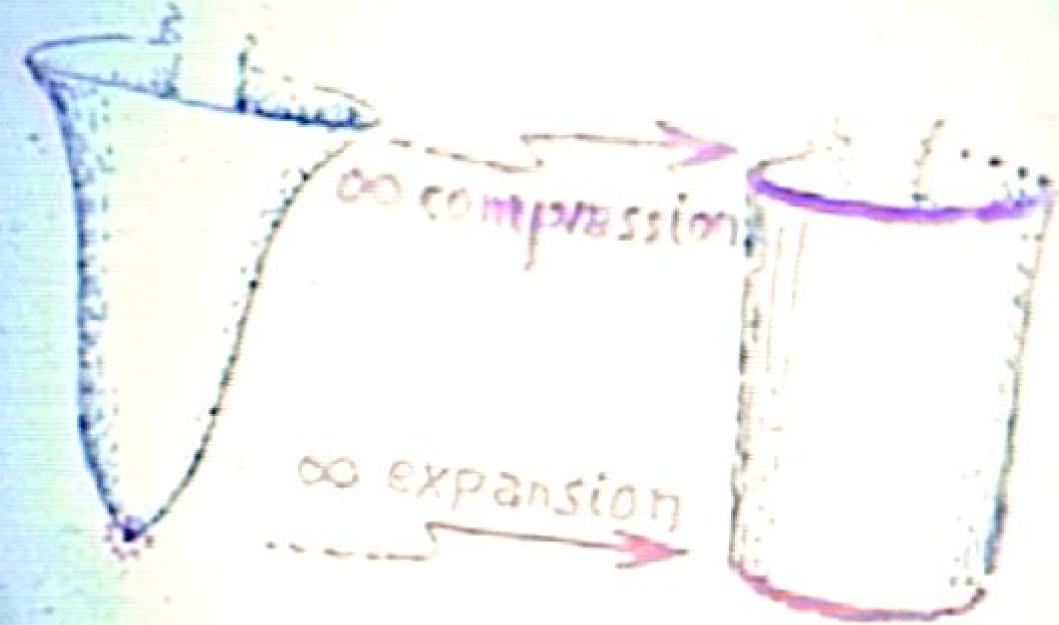
space-time extendible conformally (i.e. as light-cone structure) to BEFORE the Big Bang

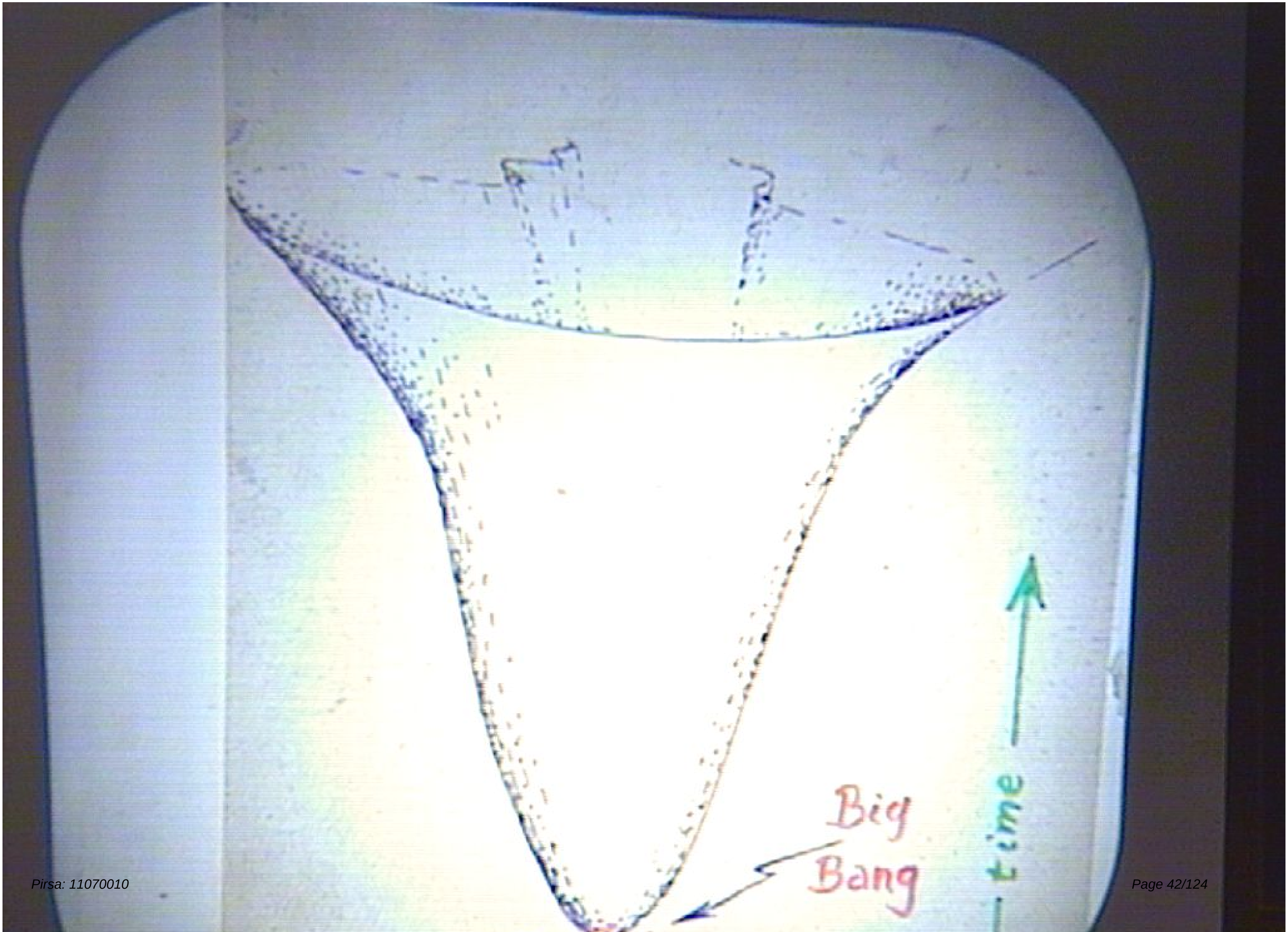


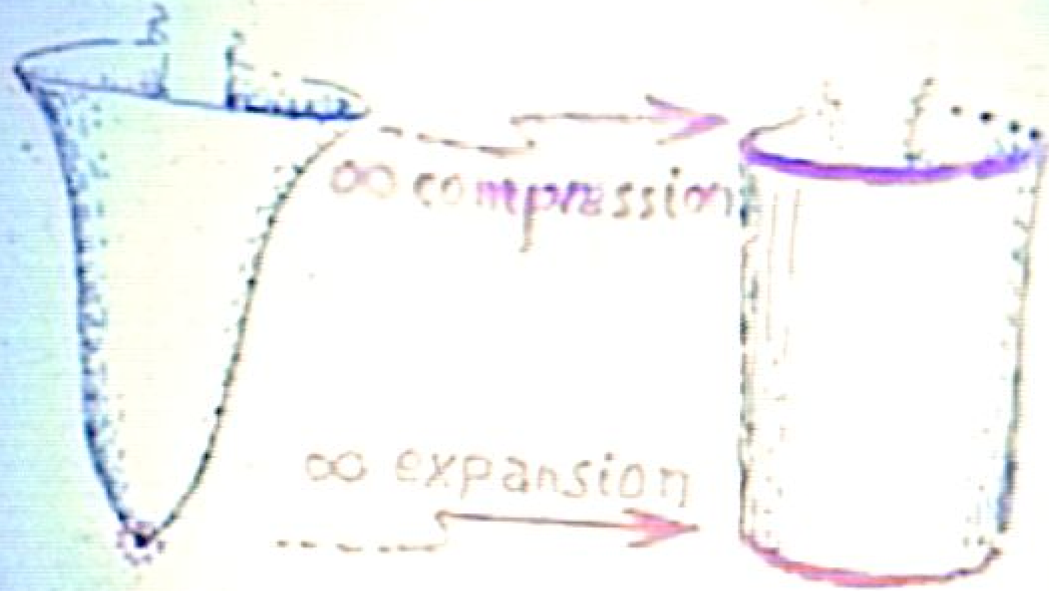
Just a mathematical trick! ? Temperatures become so large at the Big Bang that rest masses become ignorable

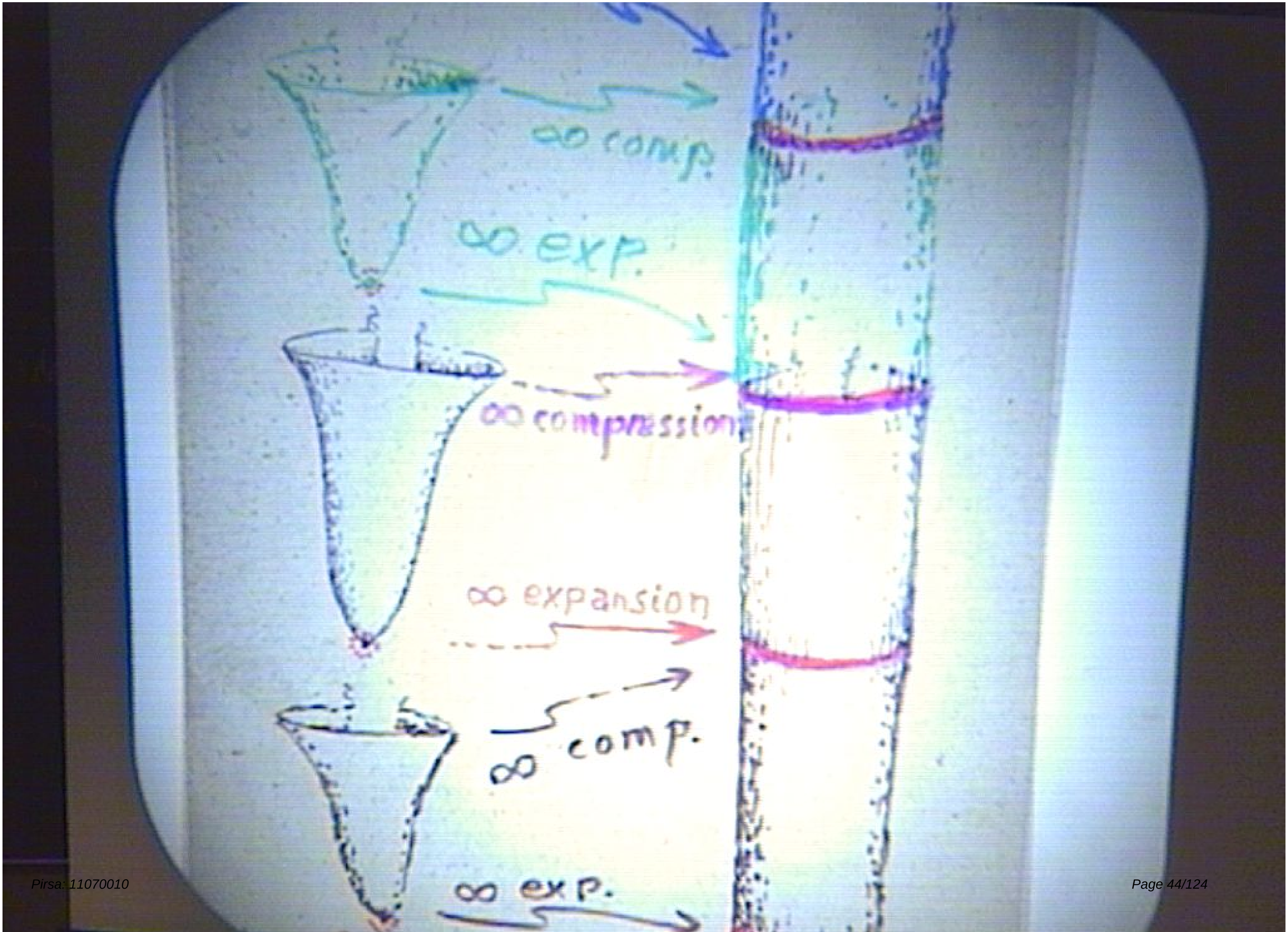
The extremely remote future


∞ compression
∞ expansion

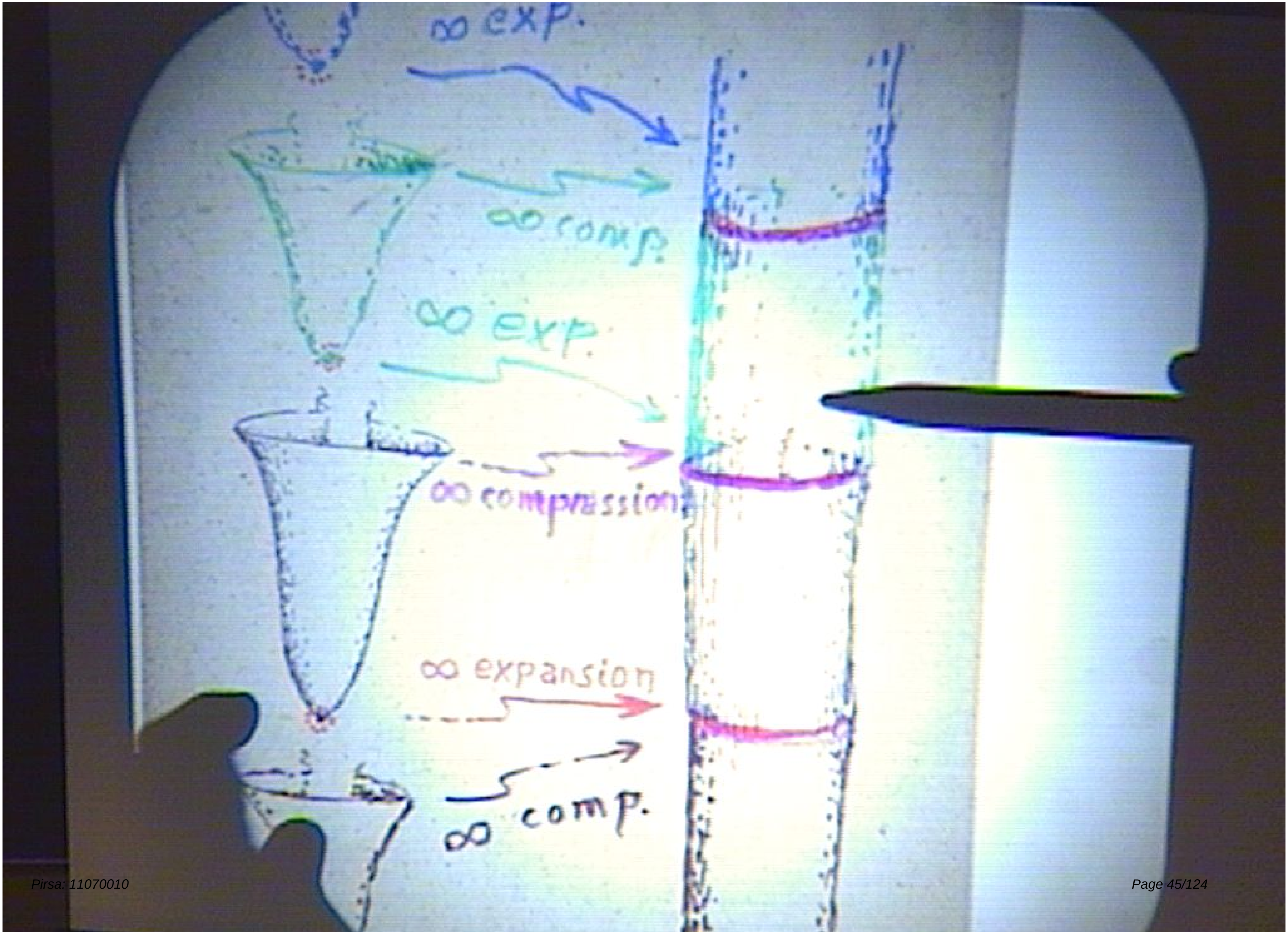

∞ compression
∞ expansion


Big
Bang
time

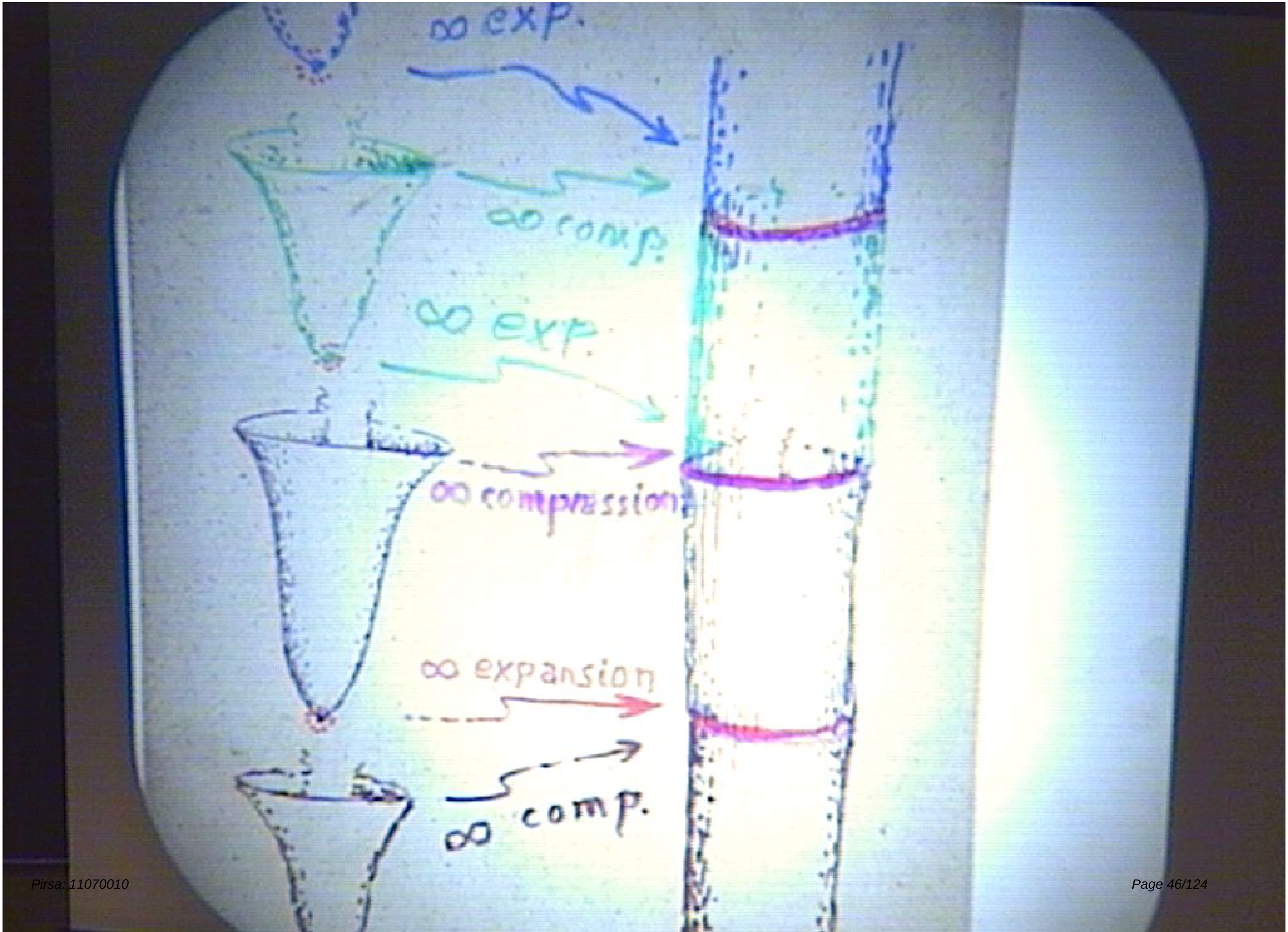

∞ compression
∞ expansion



∞ comp.
∞ exp.
∞ compression
∞ expansion
∞ comp.
∞ exp.



∞ exp.
∞ comp.
∞ exp.
∞ compression
∞ expansion
∞ comp.


∞ exp.
∞ comp.
∞ exp.
∞ compression
∞ expansion
∞ comp.

Proposal for the origin of:

- the extremely low entropy in gravitational degrees of freedom
- the detailed departures from uniformity

Conformal Cyclic Cosmology $\boxed{CCC}$

Claim: • & • both come from the evolution of purely CLASSICAL (non-quantum) p.d.e.s governing the Big Bang!

All my friends working in QG!

But, you will say: surely, near the Big Bang, space-time radii of curvature will get down to in gravitational degrees of freedom

• the detailed departures from uniformity

Conformal Cyclic Cosmology $\boxed{\text{CCC}}$

Claim: • & • both come from the evolution of purely CLASSICAL (non-quantum) p.d.e.s governing the Big Bang!

All my friends working in Q.G.

But, you will say: surely, near the Big Bang, space-time radii of curvature will get down to ~ planck length, so quantum foam, space-time chaos, discrete space-time, non-commutative geometry, ... or ???

it can't have been like this, or

• the detailed departures from uniform

Conformal Cyclic Cosmology CCC

Claim: • & • both come from the evolution of purely CLASSICAL (non-quantum) p.d.e.s governing the Big Bang!

All my friends working in Q.G.

But, you will say: surely, near the Big Bang, space-time radii of curvature will get down to ~ planck length, so quantum foam, space-time chaos, discrete space-time, non-commutative geometry, ... or ???

I say: it can't have been like this, or the extremely low-entropy conformally ... arisen.

Claim: ● & ● both come fro[m]
the evolution of purely CLASSICAL
(non-quantum) p.d.e.s governing
the Big Bang!

All my friends working in Q.G.

But, you will say: surely,
near the Big Bang, space-time radii
of curvature will get down to
~ planck length, so quantum foam,
space-time chaos, discrete space-time,
non-commutative geometry, ... or ???

I say: it can't have been like this, or
the extremely low-entropy conformally
smooth Big Bang would not have arisen.
Weyl curvature hypothesis tells us it's
radii of Weyl curvature that would need
to get down to ~planck length for foam, chaos

...e evolution of purely c...
(non-quantum) p.d.e.s governing
the Big Bang!

All my friends working in QG.

But, you will say: surely,
near the Big Bang, space-time radii
of curvature will get down to
~ planck length, so quantum foam,
space-time chaos, discrete space-time,
non-commutative geometry, ... or ???
I say: it can't have been like this, or
...e extremely low-entropy conformally
smooth Big Bang would not have arisen.
Weyl curvature hypothesis tells us it's
radii of Weyl curvature that would need
to get down to ~ planck length for foam, chaos

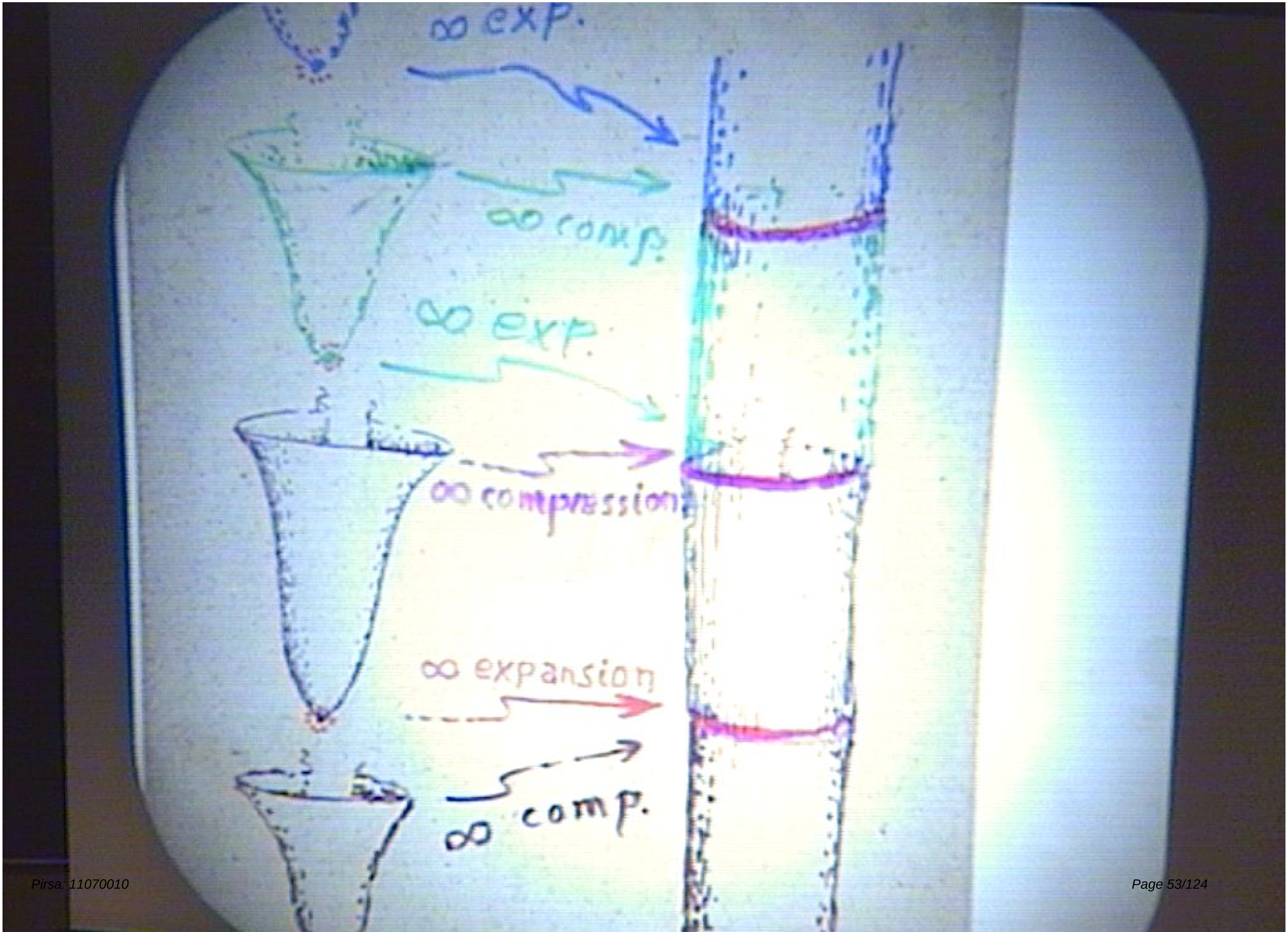
• the extremely low en[illegible]
in gravitational degrees of free[illegible]
• the detailed departures from uniformity

Conformal Cyclic Cosmology CCC

Claim: • & • both come from
the evolution of purely CLASSICAL
(non-quantum) p.d.e.s governing
the Big Bang! All my friends working in Q.G.

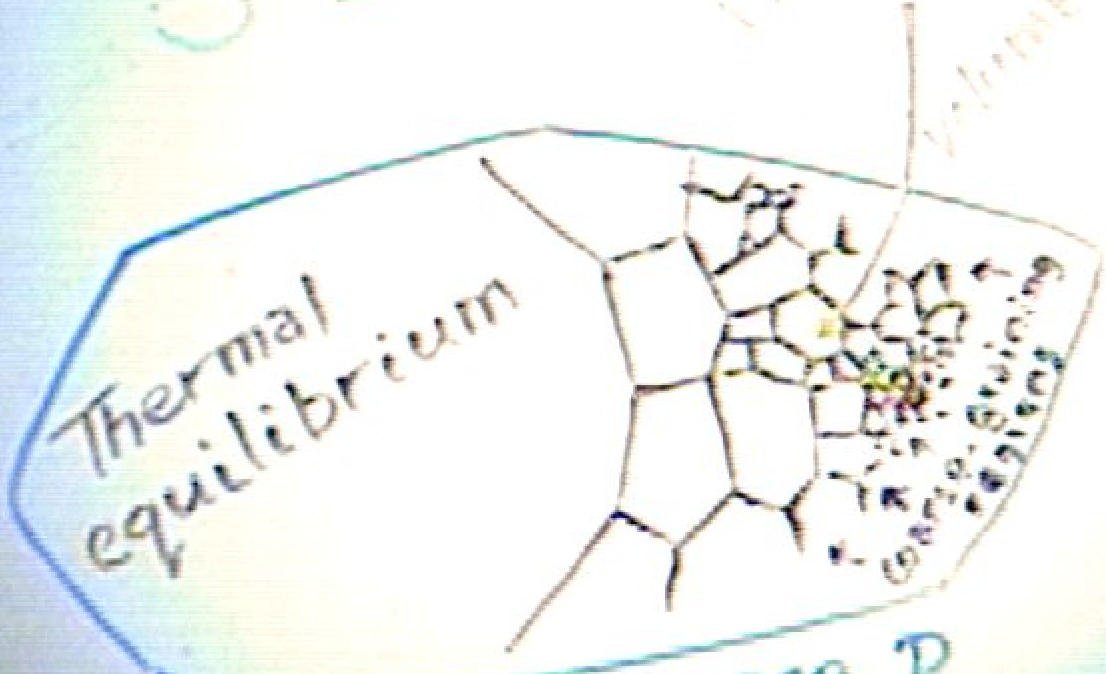
But, you will say: surely,

near the Big Bang, space-time radii
of curvature will get down to
~ planck length, so quantum foam,
space-time chaos, discrete space-time,
non-commutative geometry, ... or ???


∞ exp.
∞ comp.
∞ exp.
∞ compression
∞ expansion
∞ comp.

Boltzmann's definition of ENTROPY

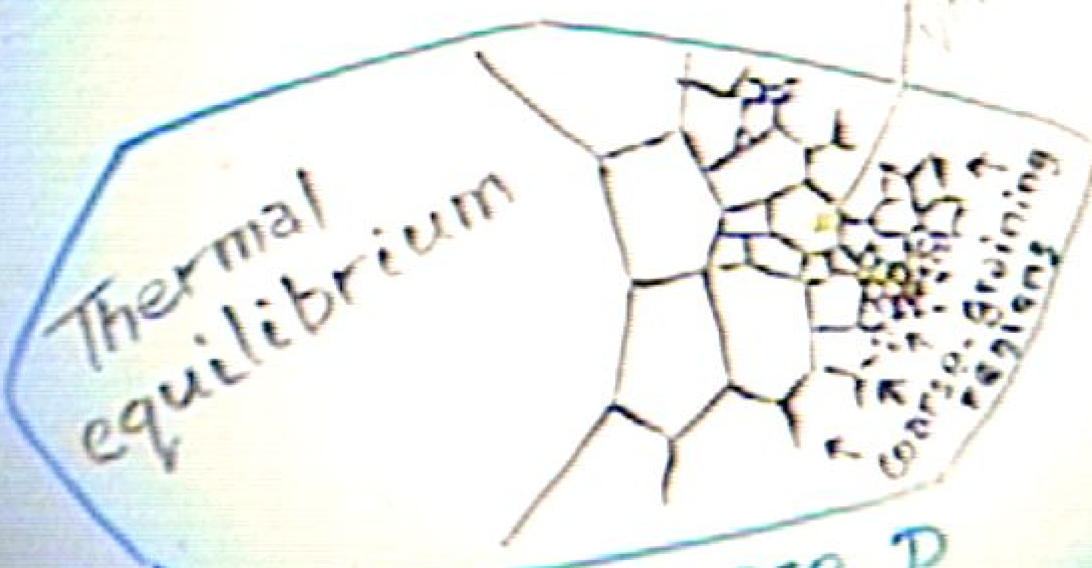
$$S = k \log V$$



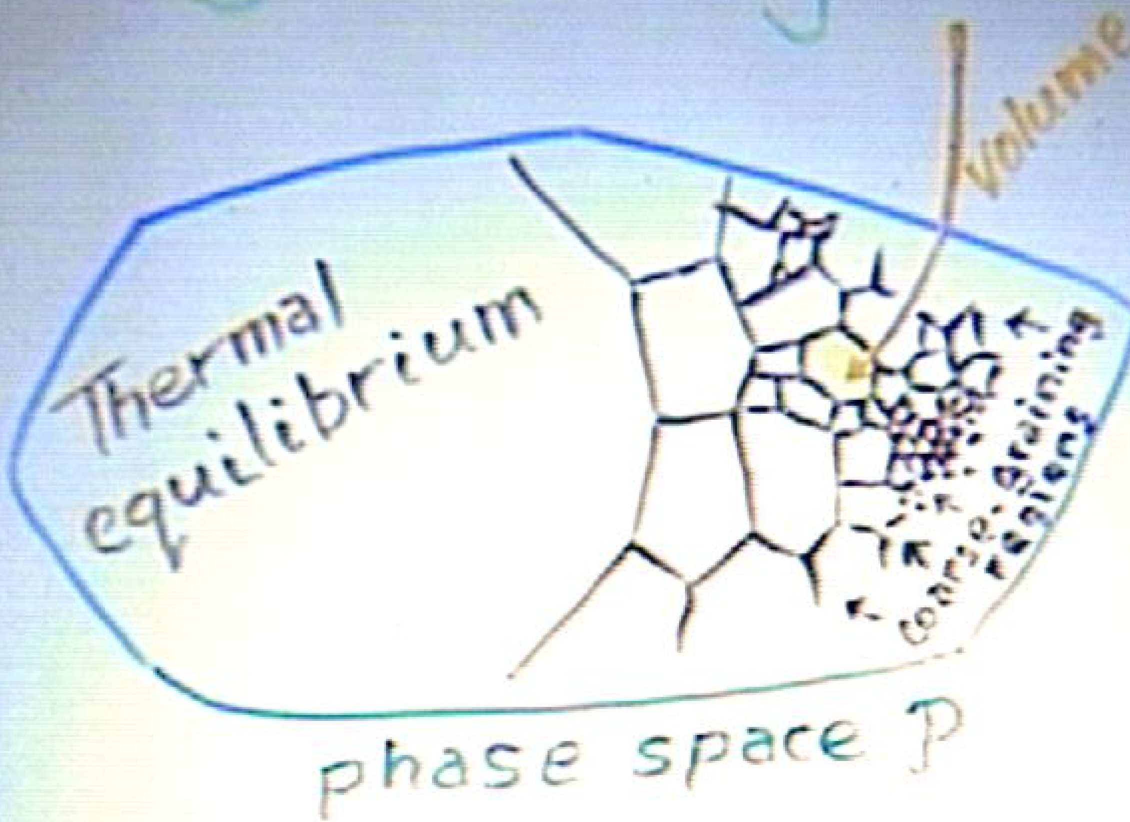
Boltzmann's definition of ENTROPY

$$S = k \log V$$

volume



$S = k \log V$

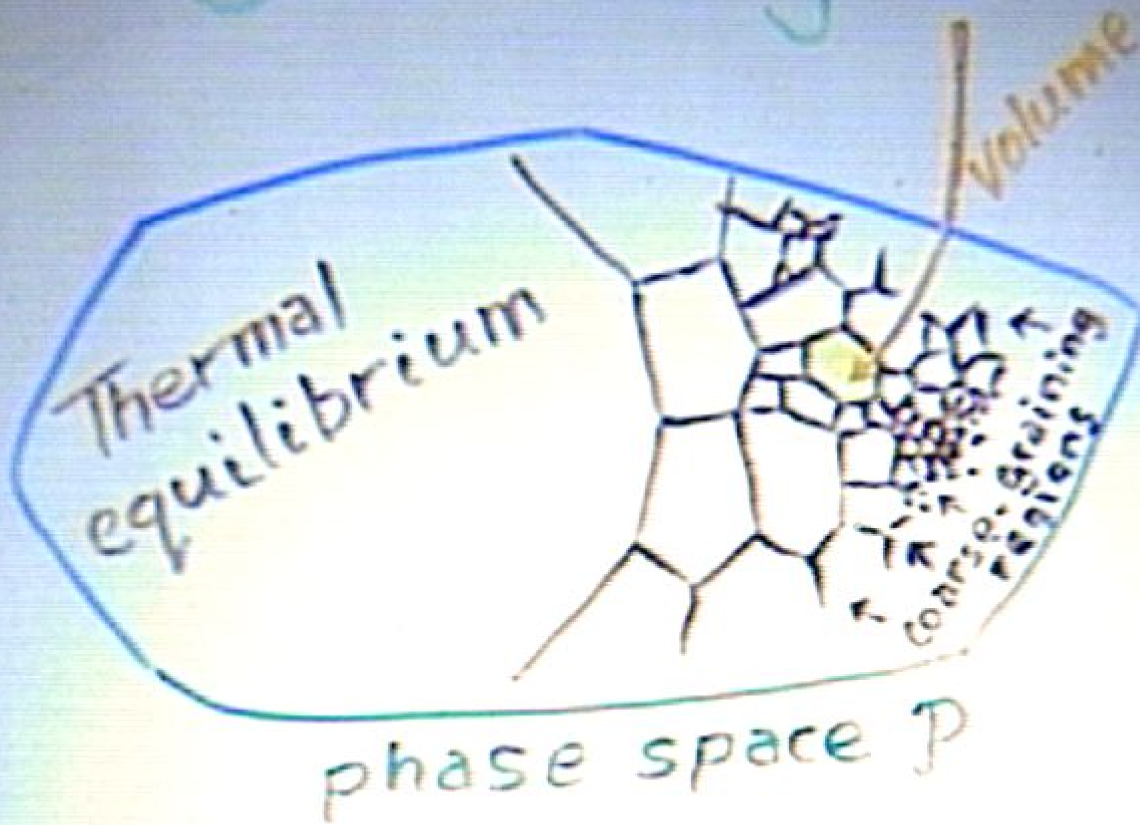


Note: $\log(VW) = \log V + \log W$

so entropy is additive

independent systems

$$S = k \log V$$



Note: $\log(VW) = \log V + \log W$

so entropy is additive for independent systems

The second law of thermodynamics: how can this be squared with a cyclic universe?

Information (i.e. phase-space volume) gets LOST at black holes' singularities agrees with the young Hawking; disagrees with the old Hawking!

Phase-space volume shrinks enormously each hole's disapearance can this be squared with a cyclic universe ?

Information (i.e. phase-space volume) gets LOST at black holes' singularities

agrees with the young Hawking; disagrees with the old Hawking!

Phase-space volume shrinks enormously with each hole's disapearance

zero of entropy gets re-set! In effect:

a cyclic universe?

Information (i.e. phase-space volume) gets LOST at black holes' singularities

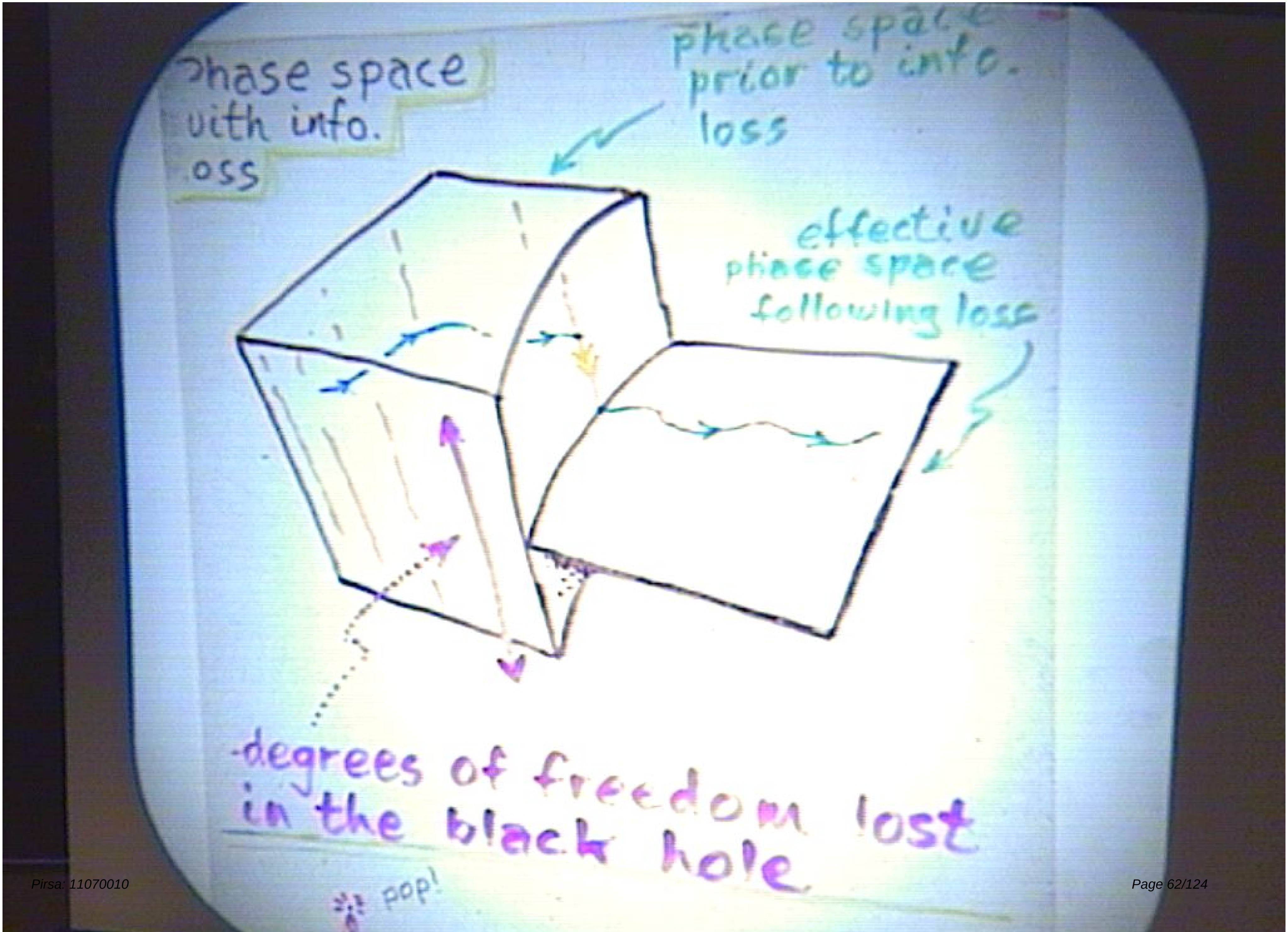
agrees with the young Hawking; disagrees with the old Hawking!

Phase-space volume shrinks enormously with each hole's disappearance

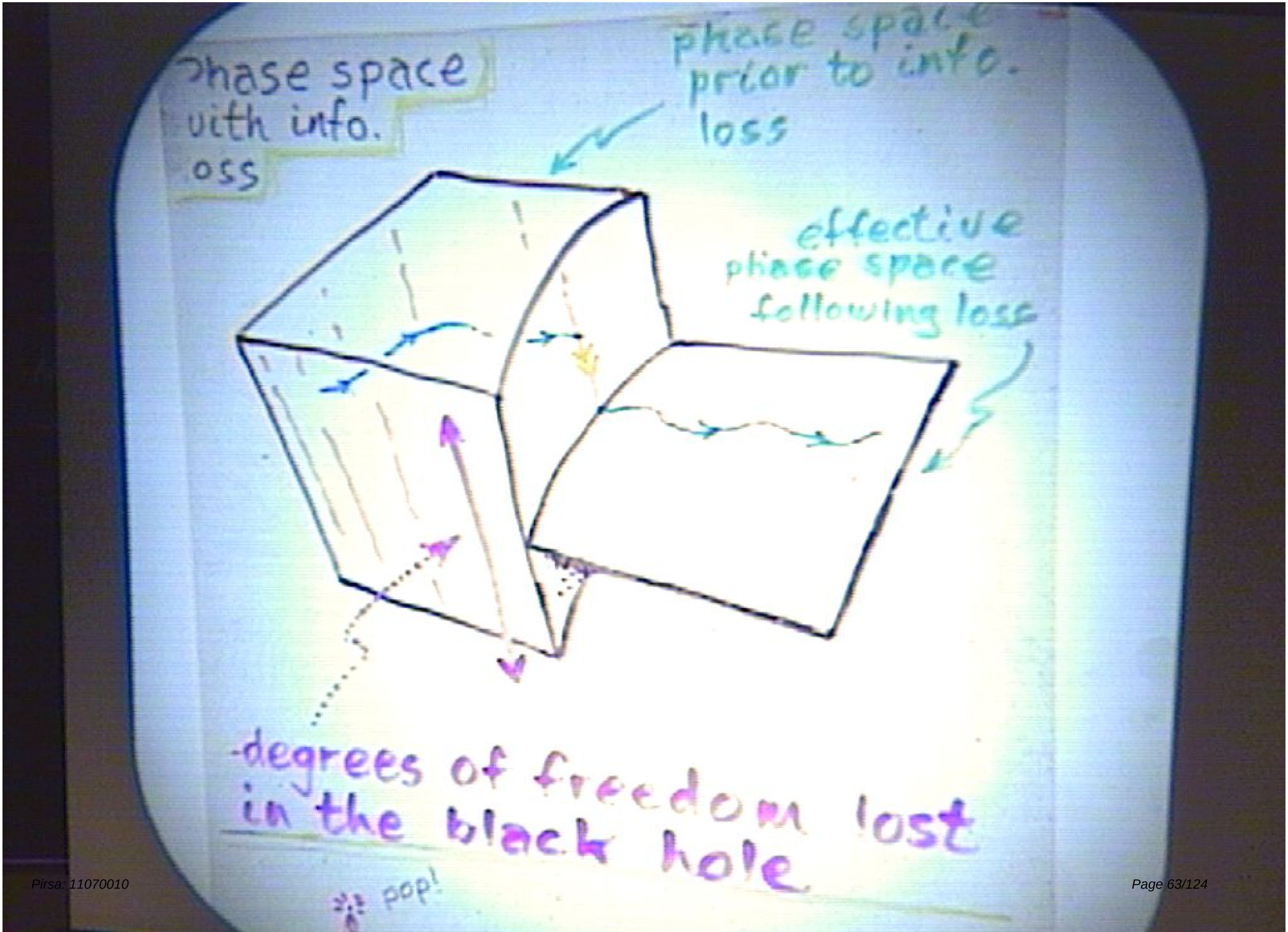
zero of entropy gets re-set! In effect: the second law is never violated despite cyclic

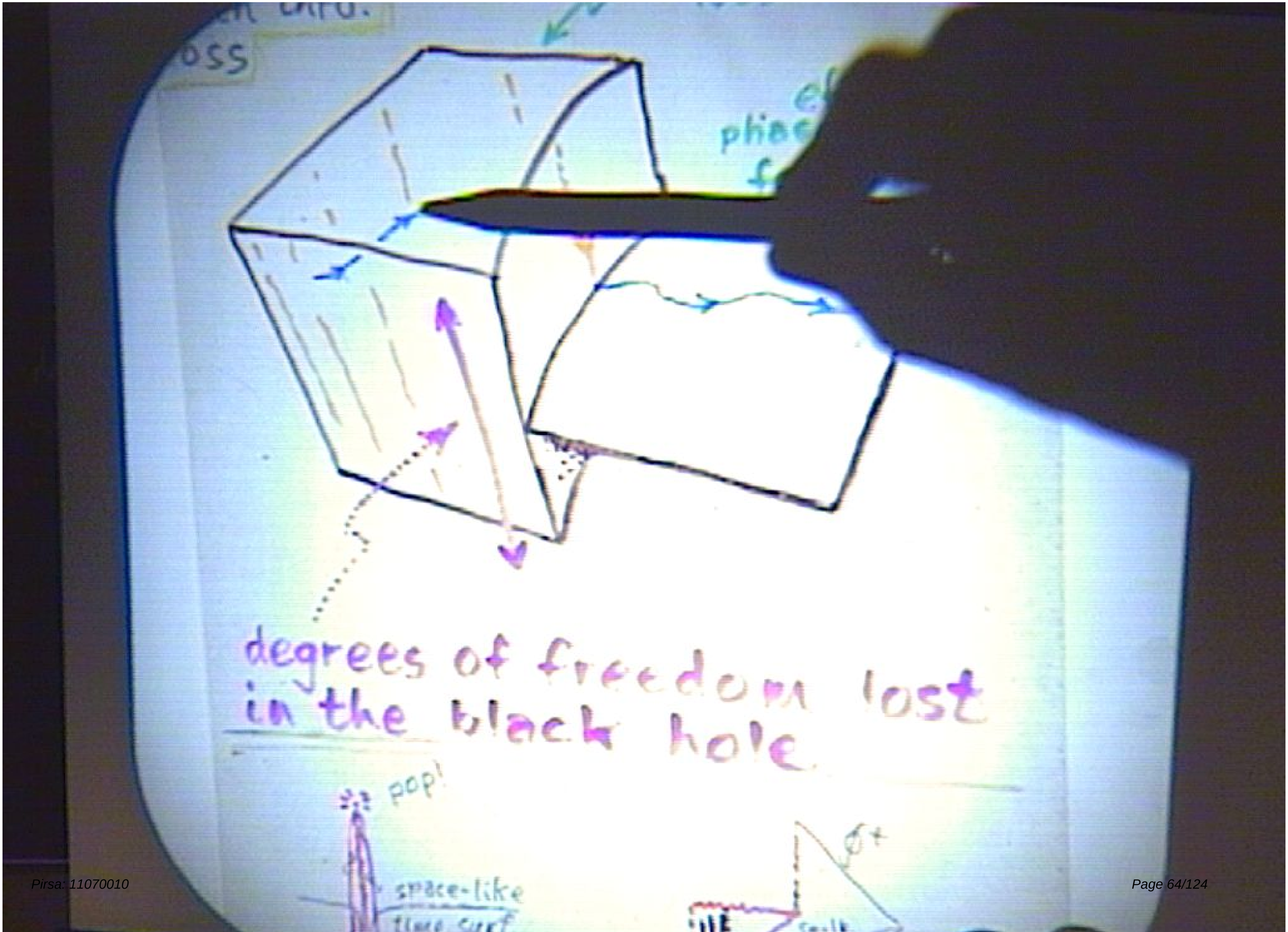
Information (i.e. phase space volume) gets LOST at black holes' singularities agrees with the young Hawking; disagrees with the old Hawking!

Phase-space volume shrinks enormously with each hole's disappearance zero of entropy gets re-set! In effect: the second law is never violated, despite cyclic nature of CCC ("transcended").

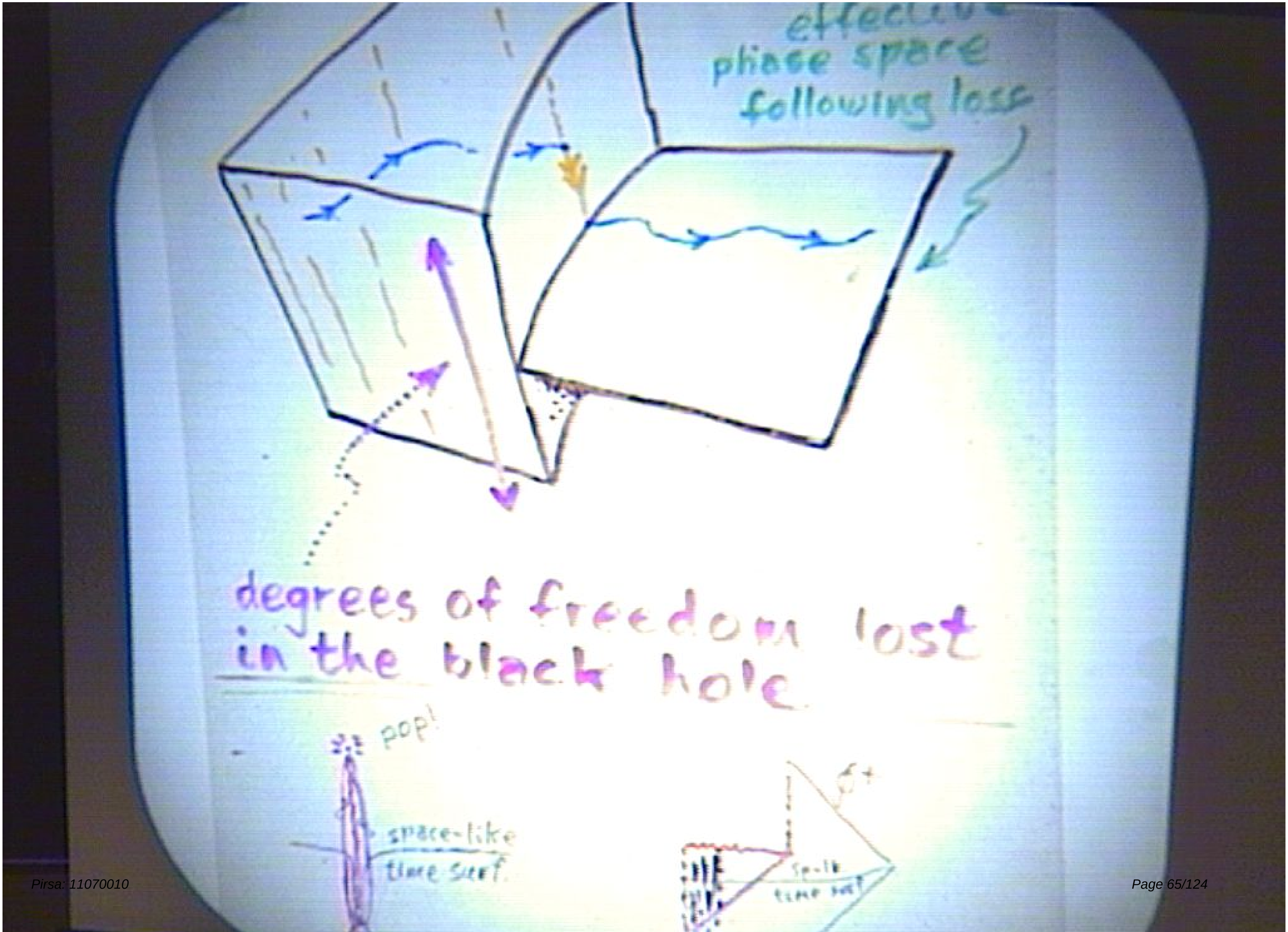


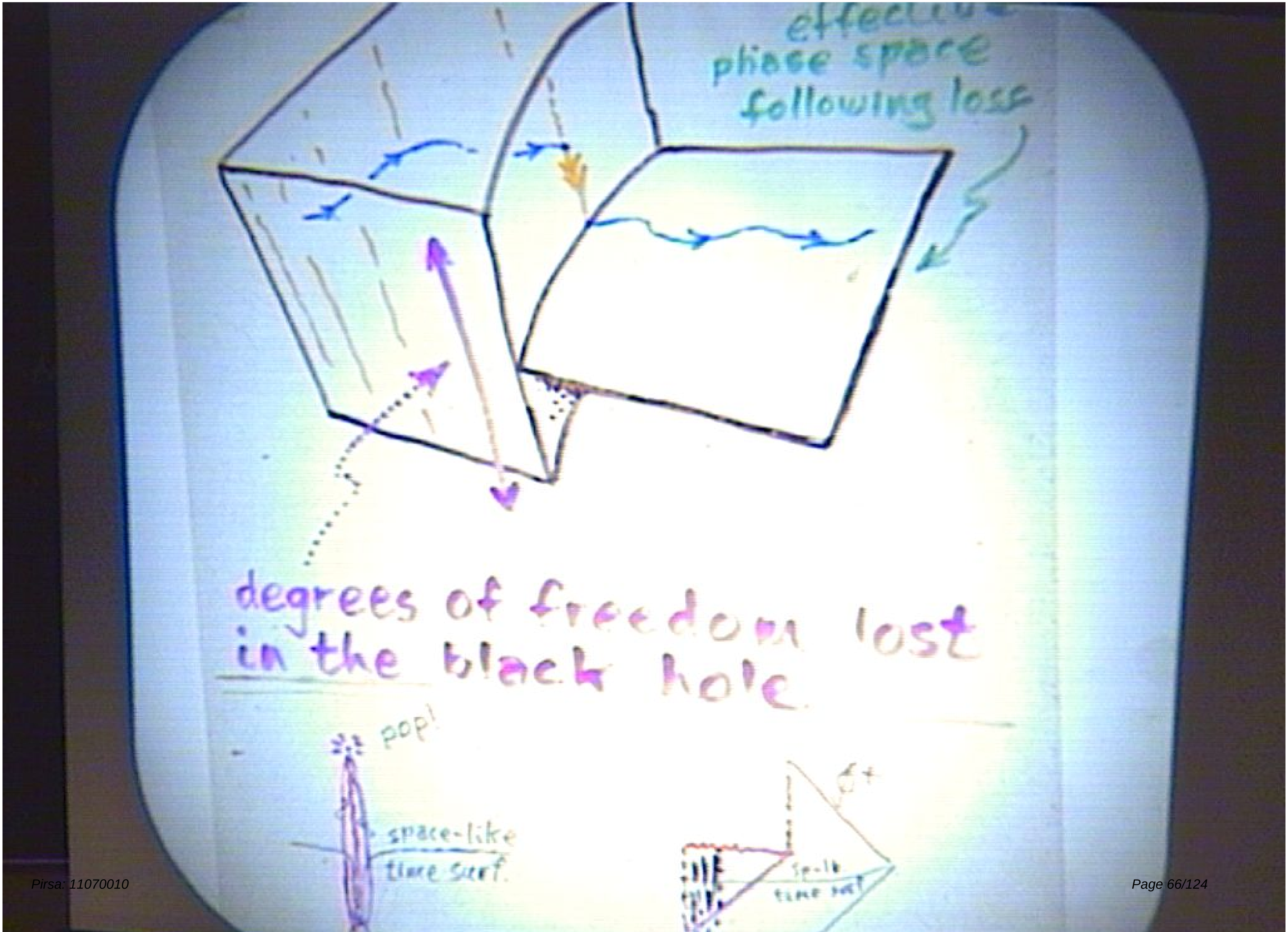
Phase space
with info.
loss
phase space
prior to info.
loss
effective
phase space
following loss
degrees of freedom lost
in the black hole
pop!


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!

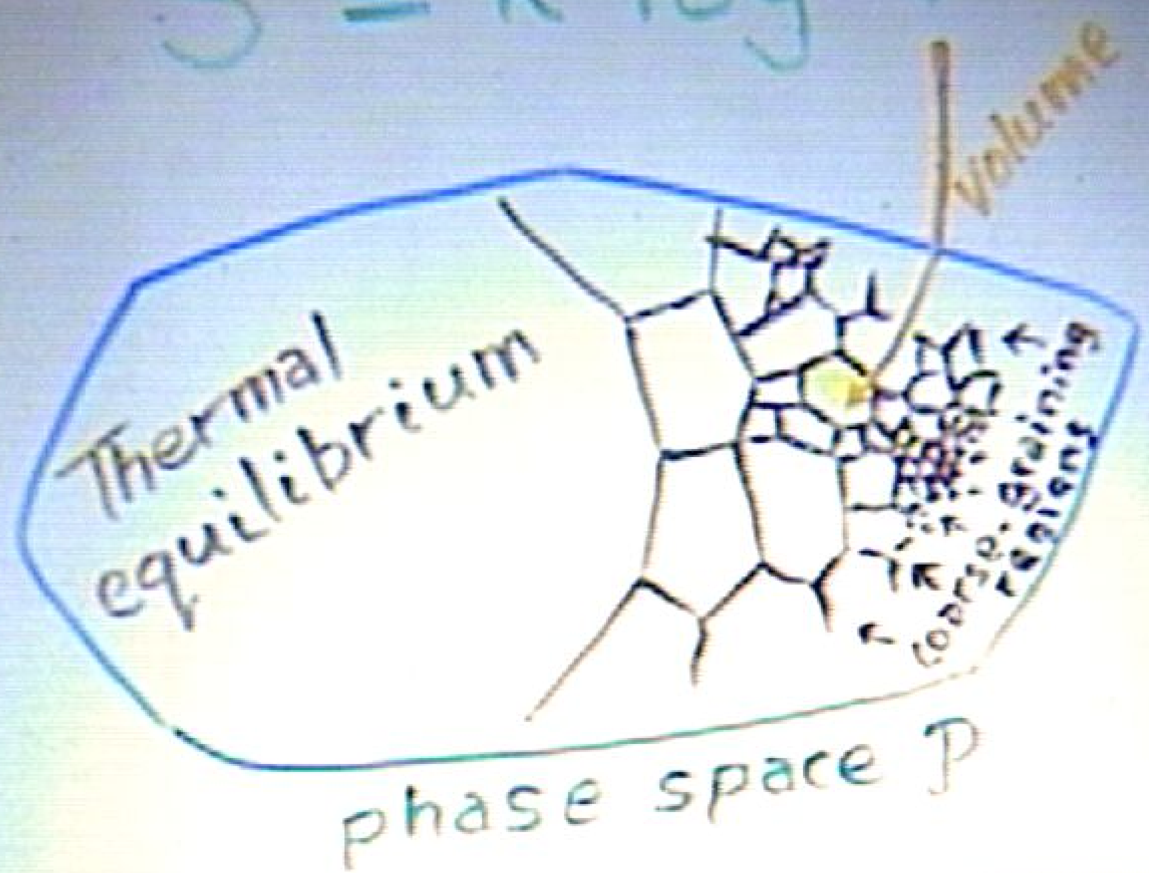


oss
phia
degrees of freedom lost in the black hole
pop!
space-like


effective
phase space
following loss
degrees of freedom lost
in the black hole
pop!
space-like
time surf.


effective
phase space
following loss
degrees of freedom lost
in the black hole
pop!
space-like
time surf.
sp-lk
time surf

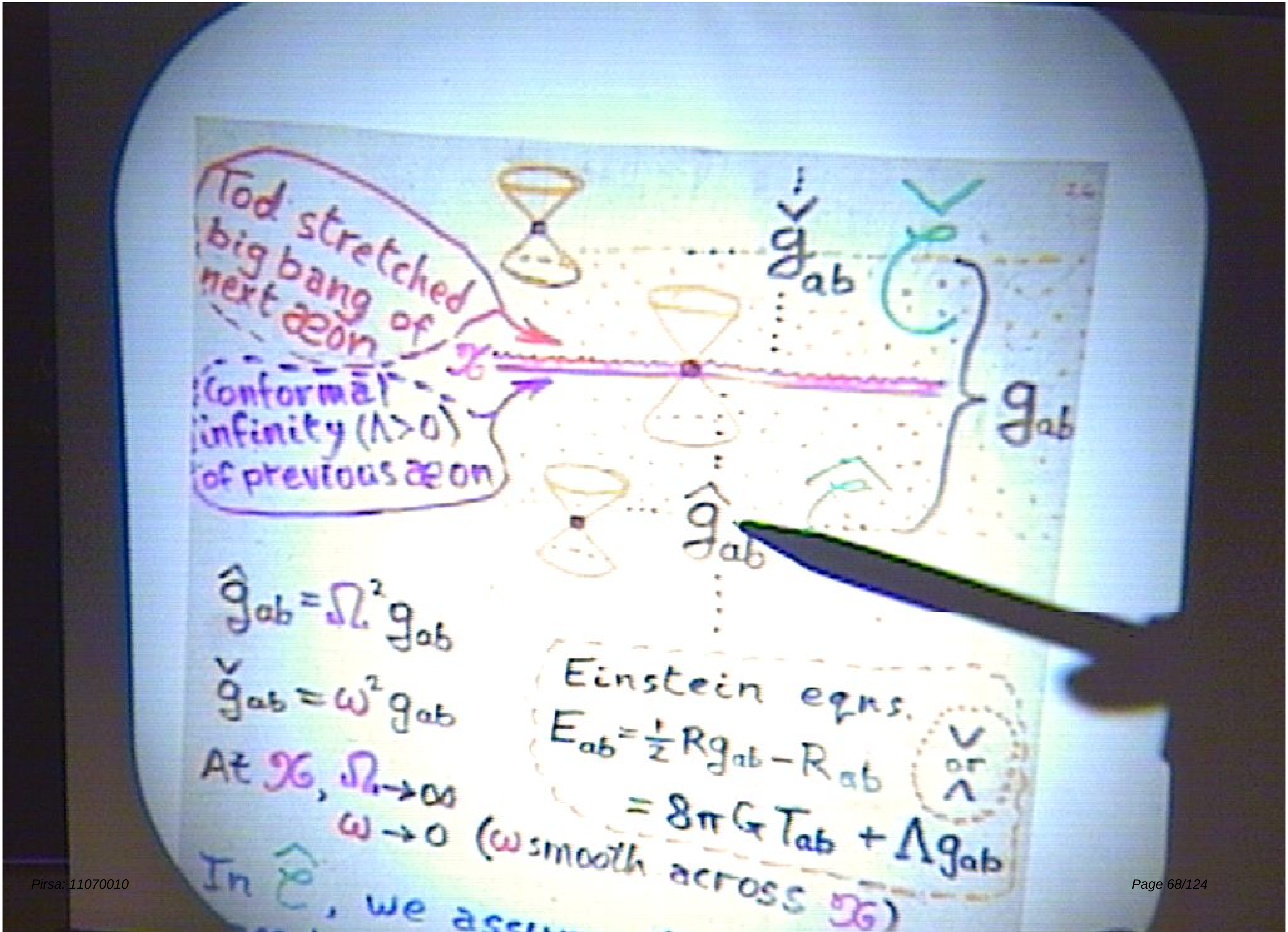
$$S \doteq k \log V$$

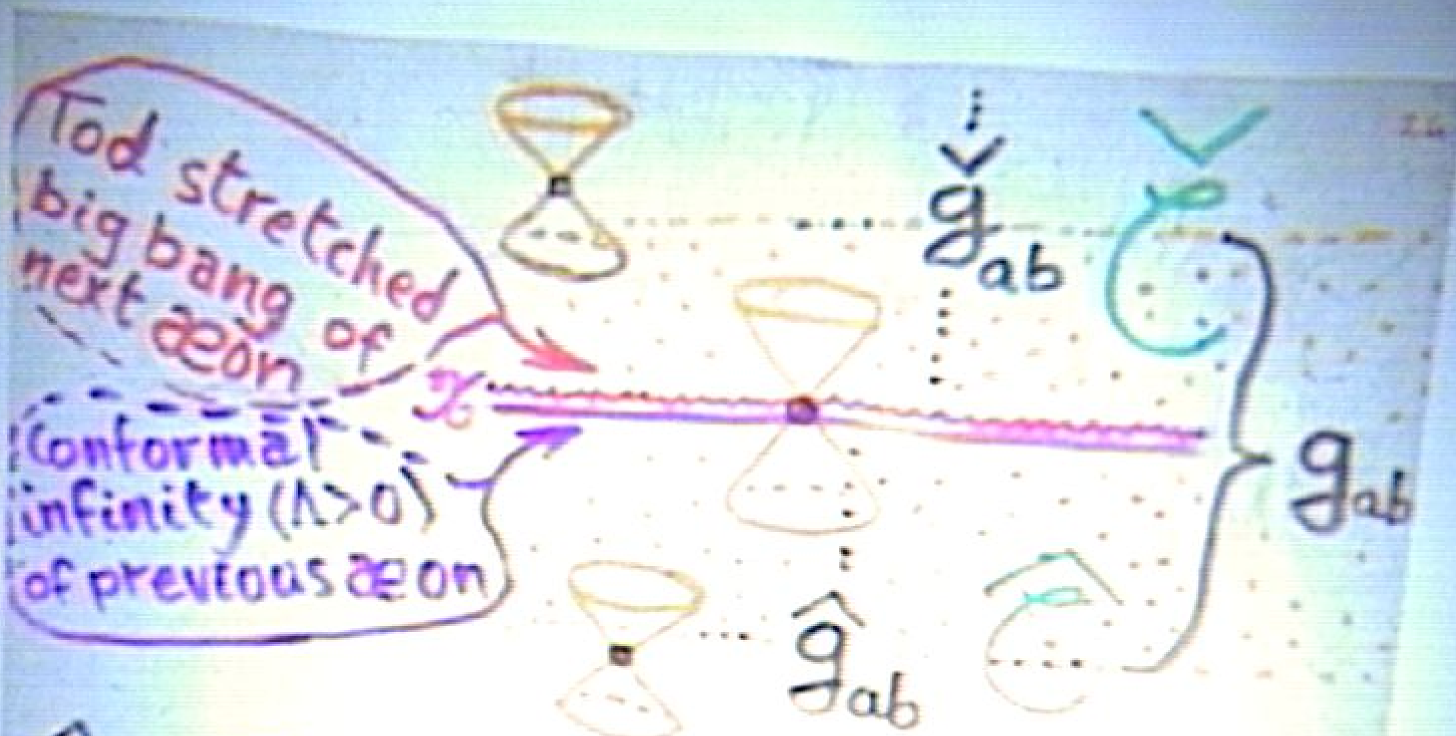


Note: $\log(VW) = \log V + \log W$

so entropy is additive

systems


Tod stretched big bang of next æon
conformal infinity (Λ>0) of previous æon
𝒳
ǧab
gab
ĝab
ĝab = Ω² gab
ǧab = ω² gab
At 𝒳, Ω → ∞
ω → 0 (ω smooth across 𝒳)
Einstein eqns.
Eab = ½ R gab − Rab
= 8πG Tab + Λ gab
ˇ or ˆ
In ℰ̂, we assu



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

$\check{g}_{ab} = \omega^2 g_{ab}$

At $\mathscr{X}$, $\Omega \to \infty$

$\omega \to 0$ (ω smooth across $\mathscr{X}$)

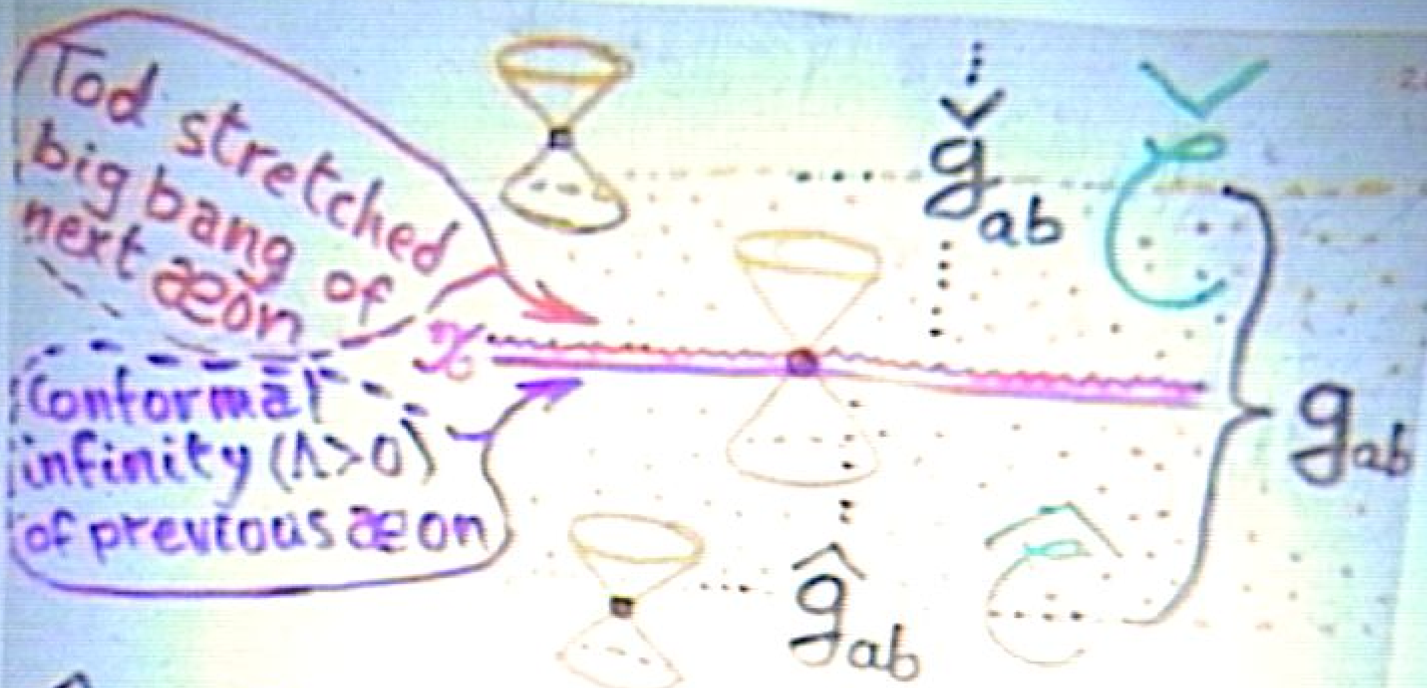
Einstein eqns.

$E_{ab} = \frac{1}{2} R g_{ab} - R_{ab}$

$= 8\pi G T_{ab} + \Lambda g_{ab}$

$\vee$ or $\wedge$

In $\hat{\mathscr{E}}$, we assu



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

$\check{g}_{ab} = \omega^2 g_{ab}$

At $\mathscr{I}$, $\Omega \to \infty$

$\omega \to 0$ (ω smooth across $\mathscr{I}$)

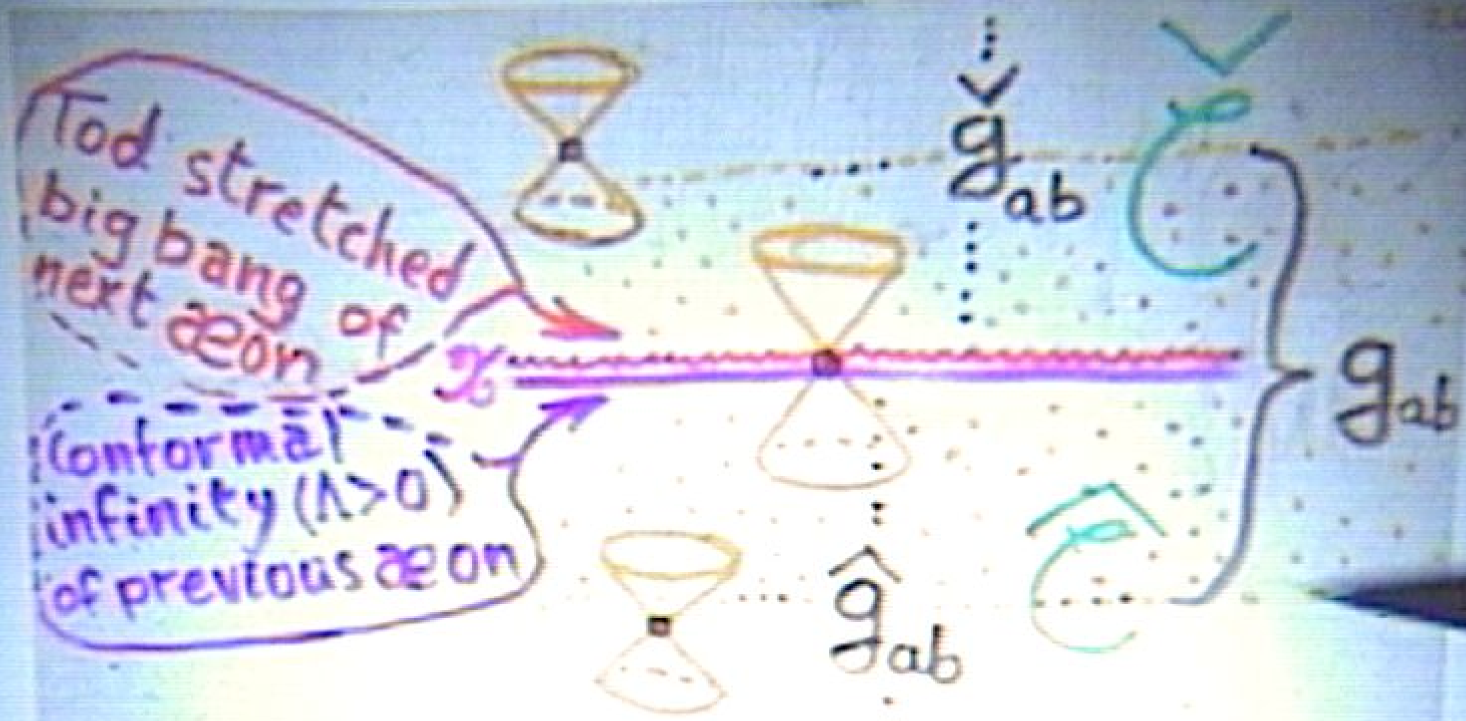
Einstein eqns.

$E_{ab} = \frac{1}{2} R g_{ab} - R_{ab}$

$= 8\pi G T_{ab} + \Lambda g_{ab}$

$\vee$ or $\wedge$

In $\hat{\mathscr{E}}$, we assum...



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

$\check{g}_{ab} = \omega^2 g_{ab}$

At $\mathscr{I}$, $\Omega \to \infty$

$\omega \to 0$ (ω smooth across $\mathscr{I}$)

Einstein eqns.

$$E_{ab} = \tfrac{1}{2} R g_{ab} - R_{ab} = 8\pi G T_{ab} + \Lambda g_{ab}$$

∨ or ∧

In $\hat{\mathcal{E}}$, we assume that all rest-mass has died away (ccc

so that

...ormal infinity ($\Lambda>0$) of previous aeon

$\hat{g}_{ab}$

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

$\check{g}_{ab} = \omega^2 g_{ab}$

At $\mathscr{X}$, $\Omega \to \infty$

$\omega \to 0$ (ω smooth across $\mathscr{X}$)

Einstein eqns. $\vee$ or $\wedge$

$$E_{ab} = \tfrac{1}{2} R g_{ab} - R_{ab}$$
$$= 8\pi G T_{ab} + \Lambda g_{ab}$$

In $\hat{\mathscr{C}}$, we assume that all rest-mass has died away (CCC hypothesis), so that $\hat{T}_a{}^a = 0$, i.e. $\hat{R} = 4\Lambda$.

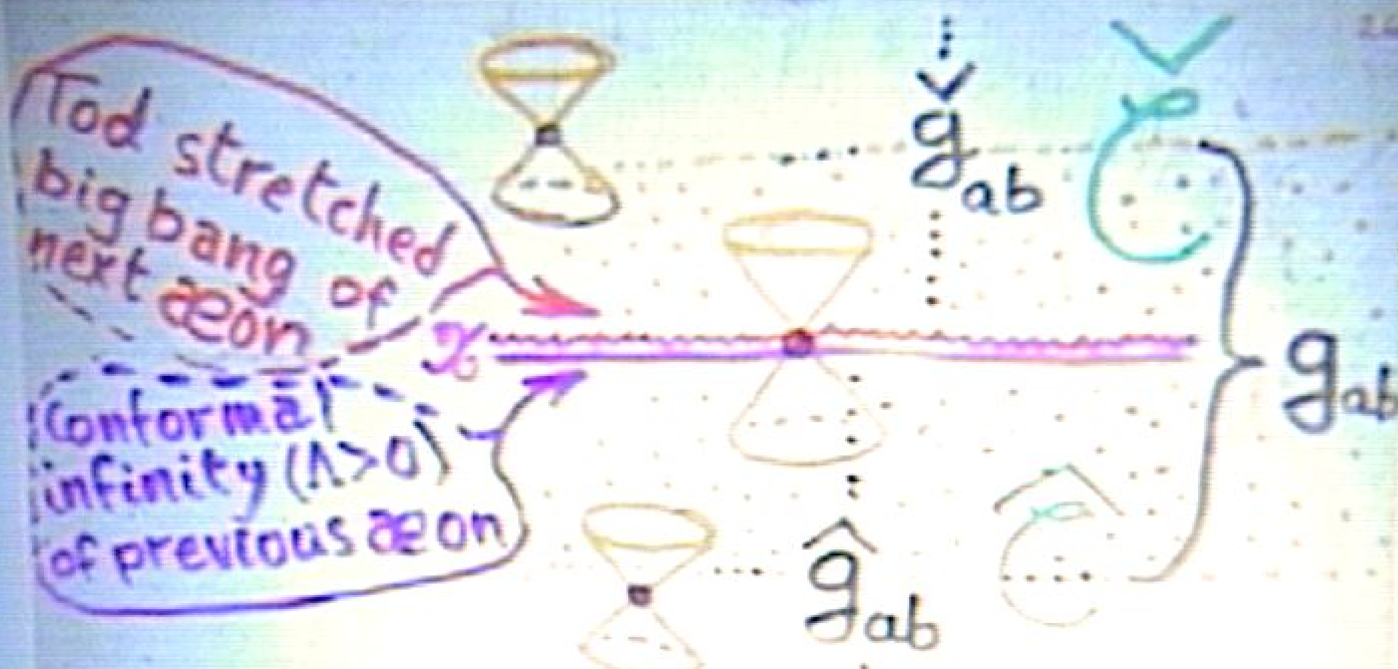
In $\hat{\mathscr{C}}$, $\check{\mathscr{C}}$, we find that the conf. invar. fields in $\hat{T}_{ab}$ scale, so that

$\hat{T}_{ab} = \Omega^{-2} T_{ab}$

$\check{T}_{ab} = \omega^{-2} T_{ab}$

Preserves $\vee$ or $\wedge$

$\nabla^a T_{ab} = 0$



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

$\check{g}_{ab} = \omega^2 g_{ab}$

At $\mathscr{X}$, $\Omega \to \infty$

$\omega \to 0$ (ω smooth across $\mathscr{X}$)

Einstein eqns. $\vee$ or $\wedge$

$$E_{ab} = \tfrac{1}{2} R g_{ab} - R_{ab}$$
$$= 8\pi G T_{ab} + \Lambda g_{ab}$$

In $\hat{\mathscr{C}}$, we ...

But we find that, in $\check{\mathscr{E}}$, $\check{T}_{ab}$ cannot be the only contribution to the energy tensor $\check{U}_{ab}$ (as I shall call it); Einstein eqns. are:

$$\hat{\mathscr{E}}: \quad \hat{E}_{ab} = 8\pi G \hat{T}_{ab} + \Lambda \hat{g}_{ab}$$

$$\check{\mathscr{E}}: \quad \check{E}_{ab} = 8\pi G \check{U}_{ab} + \Lambda \check{g}_{ab}$$

Reciprocal hypothesis:

$$\omega = -\Omega^{-1}$$

we find that $\check{U}_{ab}$ necessarily acquires a trace in $\check{\mathscr{E}}$: $\check{U}_a{}^a = \mu$, so whereas $\hat{R} = 4\Lambda$, we have $\check{R} = 4\Lambda + 8\pi G\mu$

Where does all this come from? Consider $\hat{\mathscr{E}}$ first. How

$$\hat{\mathcal{C}}: \hat{E}_{ab} = 8\pi G \hat{T}_{ab} + \Lambda \hat{g}_{ab}$$

$$\check{\mathcal{C}}: \check{E}_{ab} = 8\pi G \check{U}_{ab} + \Lambda \check{g}_{ab}$$

Reciprocal hypothesis:

$$\omega = -\Omega^{-1}$$

we find that $\check{U}_{ab}$ necessarily acquires a trace in $\check{\mathcal{C}}$: $\check{U}_a{}^a = \mu$, so whereas $\hat{R} = 4\Lambda$, we have $\check{R} = 4\Lambda + 8\pi G\mu$

Where does all this come from? Consider $\hat{\mathcal{C}}$ first. How do we write the Ein. eqns. in the g_{ab} metric? If we want g to have the same "cosmol. const." Λ, i.e. $R = 4\Lambda$ (as well as $\hat{R} = 4\Lambda$), then we find that $\varpi = \Omega$ sats. the "ϖ-eqn":

$$\left(\Box + \frac{R}{6}\right)\varpi = \frac{2}{3}\Lambda\varpi^3$$

$\omega = -\Omega.$

we find that $\check{U}_{ab}$ necessarily acquires a trace in $\check{\mathcal{E}}$: $\check{U}_a{}^a = \mu$, so whereas $\hat{R} = 4\Lambda$, we have $\check{R} = 4\Lambda + 8\pi G\mu$

Where does all this come from? Consider $\hat{\mathcal{E}}$ first. How do we write the Ein. eqns. in the g_{ab} metric? If we want g to have the same "cosmol. const." Λ, i.e. $R = 4\Lambda$ (as well as $\hat{R} = 4\Lambda$), then we find that $\varpi = \Omega$ sats. the "ϖ-eqn":

$$\left(\Box + \frac{R}{6}\right)\varpi = \frac{2}{3}\Lambda\varpi^3$$

we find that $\check{U}_{ab}$ necessarily acquires a trace in $\check{\mathcal{E}}$: $\check{U}_a{}^a = \mu$, so whereas $\hat{R} = 4\Lambda$, we have $\check{R} = 4\Lambda + 8\pi G\mu$

Where does all this come from? Consider $\hat{\mathcal{E}}$ first. How do we write the Ein. eqns. in the g_{ab} metric? If we want g to have the same "cosmol. const." Λ, ie. $R = 4\Lambda$ (as well as $\hat{R} = 4\Lambda$), then we find that $\varpi = \Omega$ sats. the "ϖ-eqn.":

$$\left(\Box + \frac{R}{6}\right)\varpi = \frac{2}{3}\Lambda\varpi^3$$

This is a conf. invar. self-coupled scalar eqn., since if

$$\tilde{\varpi} = \tilde{\Omega}^{-1}\varpi ,$$

then

$$\left(\tilde{\Box} + \frac{\tilde{R}}{6}\right)\tilde{\varpi} = \tilde{\Omega}^{-3}\left(\Box + \frac{R}{6}\right)\varpi$$

The energy ("new improved") tensor for ϖ is:

Callan Coleman
Jakiw
Newman-RP

$$T_{ab}[\varpi] = \frac{1}{4\pi G}\varpi^{2}\left\{\varpi\nabla_{\langle a}\nabla_{b\rangle}\varpi^{-1} - \frac{1}{2}R_{\langle ab\rangle}\right\}$$

specific choice of const. made

$\langle\cdot\cdot\rangle$ = trace-removed symetric part

Einstein eqns. in $\hat{}$, in terms of g_{ab} are:

$$\boxed{T_{ab} = T_{ab}[\varpi]}$$

Call ϖ the "phantom field"

Ein. eqns. in g.. metric take the form

"energy tensor of matter = energy tensor of phantom field"

This is a conf. invar. self-coupled scalar eqn., since if

$$\tilde{\varpi} = \tilde{\Omega}^{-1}\varpi ,$$

then

$$\left(\tilde{\Box}+\frac{\tilde{R}}{6}\right)\tilde{\varpi} = \tilde{\Omega}^{-3}\left(\Box+\frac{R}{6}\right)\varpi$$

The energy ("new improved") tensor for ϖ is:

Callan Coleman
Jakiw
Newman-RP

$$T_{ab}[\varpi] = \frac{1}{4\pi G}\varpi^{2}\left\{\varpi\nabla_{\langle a}\nabla_{b\rangle}\varpi^{-1} - \frac{1}{2}R_{\langle ab\rangle}\right\}$$

Specific choice of const. made

$\langle\cdot\ \cdot\rangle$ = trace-removed symmetric part

Einstein eqns. in $\hat{\ }$, in terms of g_{ab} are:

$$\boxed{T_{ab} = T_{ab}[\Omega]}$$

Call Ω the "phantom field"

Ein. eqns. in $g_{..}$ metric take the form:

"energy tensor of matter = energy tensor of phantom field."

The reciprocal hypoth...

$$\hat{\omega} = \hat{\Omega}^{-1}\omega ,$$

then $$\left(\hat{\Box}+\frac{\hat{R}}{6}\right)\hat{\omega} = \hat{\Omega}^{-3}\left(\Box+\frac{R}{6}\right)\omega$$

The energy ("new improved") tensor for ω is:

Callan Coleman Jakiw Newman-RP

$$T_{ab}[\omega] = \frac{1}{4\pi G}\omega^{2}\left\{\omega\nabla_{\langle a}\nabla_{b\rangle}\omega^{-1}-\frac{1}{2}R_{\langle ab\rangle}\right\}$$

Specific choice of const. made

$\langle \cdot\cdot \rangle$ = trace-removed symetric part

Einstein eqns. in $\hat{g}$, in terms of g_{ab} are:

$$\boxed{T_{ab} = T_{ab}[\Omega]}$$

Call Ω the "phantom field"

Ein. eqns. in g.. metric take the form:

"energy tensor of matter = energy tensor of phantom field."

The reciprocal hypothesis allows us to re-interpret the scalar eqn., since if

$$\tilde{\phi} = \tilde{\Omega}^{-1}\phi ,$$

then $$\left(\tilde{\Box}+\frac{\tilde{R}}{6}\right)\tilde{\phi} = \tilde{\Omega}^{-3}\left(\Box+\frac{R}{6}\right)\phi$$

The energy ("new improved") tensor for ϕ is: / Callan Coleman Jackiw / Newman RP

$$T_{ab}[\phi] = \frac{1}{4\pi G}\phi^2\{\phi\nabla_{(a}\nabla_{b)}\phi^{-1} - \tfrac{1}{2}R_{\langle ab\rangle}\}$$

specific choice of const. made

$\langle\cdot\,\cdot\rangle$: trace-removed symmetric part

Einstein eqns in $\hat{g}$, in terms of g_{ab} are:

$$\boxed{T_{ab} = T_{ab}[\Omega]}$$

Call Ω the "phantom field"

Ein. eqns. in $g_{..}$ metric take the form:
"energy tensor of matter = energy tensor of phantom field."

The reciprocal hypothe[sis] allows us to re-interpret ...

Then $\left(\tilde{\Box}+\frac{\tilde{R}}{6}\right)\tilde{\phi} = \Omega^{-3}\left(\Box+\frac{R}{6}\right)\phi$

The energy ("new improved") tensor for ϕ is:

Callan Coleman
Jakiw
Newman-RP

$$T_{ab}[\phi] = \frac{1}{4\pi G}\phi^{2}\left\{\phi\nabla_{\langle a}\nabla_{b\rangle}\phi^{-1} - \frac{1}{2}R_{\langle ab\rangle}\right\}$$

Specific choice of const. made

$\langle\cdot\,\cdot\rangle$ = trace-removed symetric part

Einstein eqns. in $\hat{\mathcal{E}}$, in terms of g_{ab} are:

$$\boxed{T_{ab} = T_{ab}[\Omega]}$$

Call Ω the "phantom field"

Ein. eqns. in g.. metric take the form:
"energy tensor of matter = energy tensor of phantom field."

The reciprocal hypothesis allows us to re-interpret the phantom field as a real field in $\check{\mathcal{E}}$ which satisfies

$$\hat{\mathcal{E}}: \hat{E}_{ab} = 8\pi G \hat{T}_{ab} + \Lambda \hat{g}_{ab}$$

$$\check{\mathcal{E}}: \check{E}_{ab} = 8\pi G \check{U}_{ab} + \Lambda \check{g}_{ab}$$

Reciprocal hypothesis:

$$\omega = -\Omega^{-1}$$

we find that $\check{U}_{ab}$ necessarily acquires a trace in $\check{\mathcal{E}}$: $\check{U}_a{}^a = \mu$, so whereas $\hat{R} = 4\Lambda$, we have $\check{R} = 5\Lambda + 8\pi G\mu$

Where does all this come from? Consider $\hat{\mathcal{E}}$ first. How do we write the Ein. eqns. in the g_{ab} metric? If we want g to have the same "cosmol. const." Λ, i.e. $R = 4\Lambda$ (as well as $\hat{R} = 4\Lambda$), then we find that $\omega = \Omega$ sats. the

$\hat{\mathscr{E}}$: $\hat{E}_{ab} = 8\pi G \hat{T}_{ab} + \Lambda \hat{g}_{ab}$

$\check{\mathscr{E}}$: $\check{E}_{ab} = 8\pi G \check{U}_{ab} + \Lambda \check{g}_{ab}$

Reciprocal hypothesis:

$$\omega = -\Omega^{-1}$$

we find that $\check{U}_{ab}$ necessarily acquires a trace in $\check{\mathscr{E}}$: $\check{U}_a{}^a = \mu$, so whereas $\hat{R} = 4\Lambda$, we have $\check{R} = 4\Lambda + 8\pi G\mu$

Where does all this come from? Consider $\hat{\mathscr{E}}$ first. How do we write the Ein. eqns. in the g_{ab} metric? If we want g to have the same "cosmol. const." Λ, i.e. $R = 4\Lambda$ (as well as $\hat{R} = 4\Lambda$), then we find that $\omega = \Omega$ sats. the

However, we now find that the equ. is the wrong way around to preserve the trace " $\check{U}_a{}^a = 4\Lambda$ " and instead we find that there is a rest-mass contribution to the total energy tensor in $\check{\mathcal{E}}$

$$\check{U}_{ab} = \check{T}_{ab} + \check{V}_{ab} + \check{W}_{ab}$$

Total

massless fields from $\check{\mathcal{E}}$

energy tensor of phantom fld. become real

remaining piece, which has the trace μ

We find:

$$\mu = \frac{(\Omega^{-2}-1)}{2\pi G}\{3\Pi^a\Pi_a - \Lambda\}$$

The 1-form

$$\Pi = \frac{d\Omega}{\Omega^2-1} = \frac{d\omega}{\dots}$$

Seems ...

to preserve the trace $U_a = 4\pi$ ...
and instead we find that there is a rest-mass contribution to the total energy tensor in $\check{\mathcal{E}}$

$$\check{U}_{ab} = \check{T}_{ab} + \check{V}_{ab} + \check{W}_{ab}$$

Total

massless fields from $\check{\mathcal{E}}$

energy tensor of phantom fld. become real

remaining piece, which has the trace μ

We find:

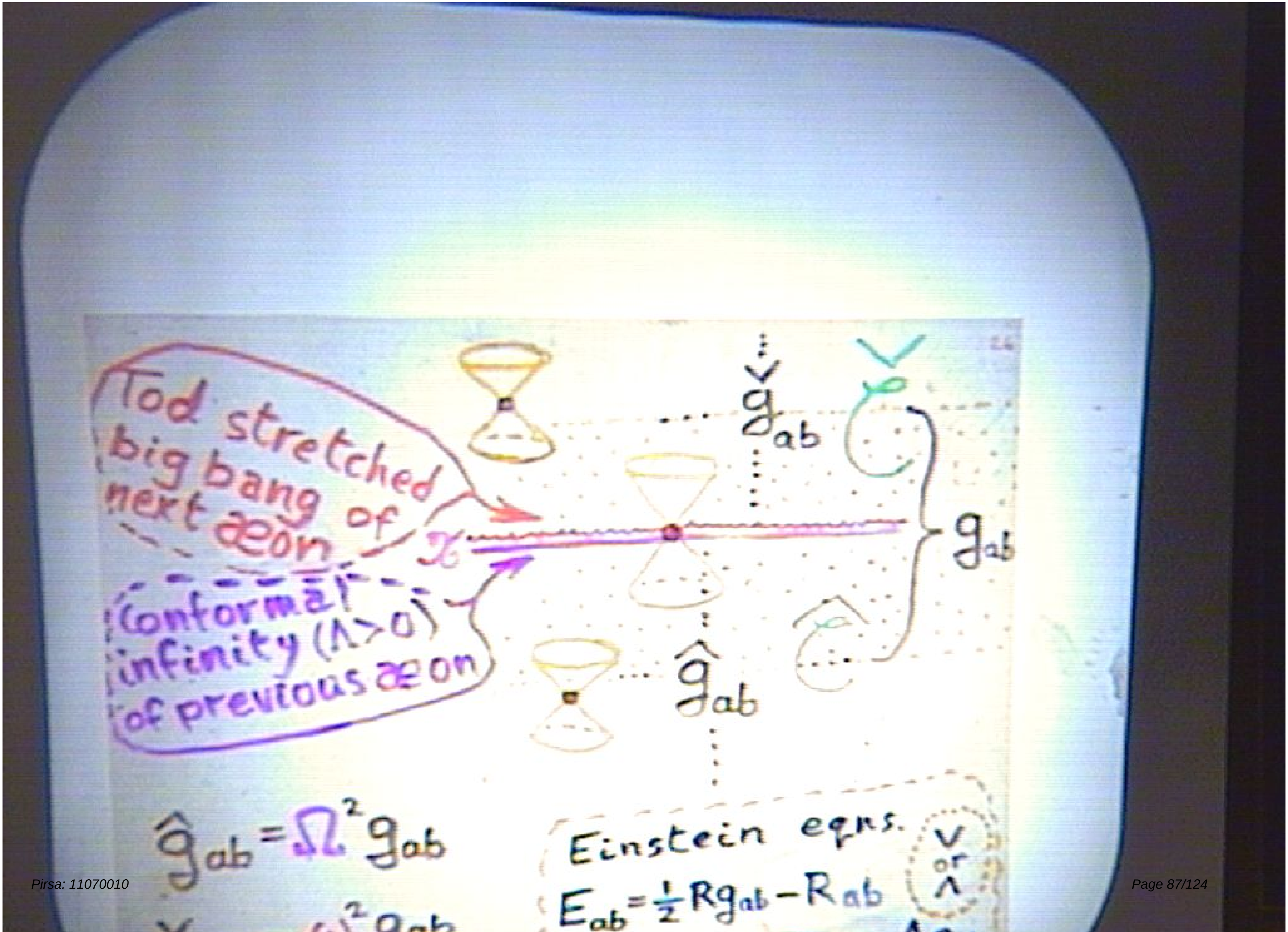
$$\mu = \frac{(\Omega^2-1)}{2\pi G}\{3\Pi^a\Pi_a - \Lambda\}$$

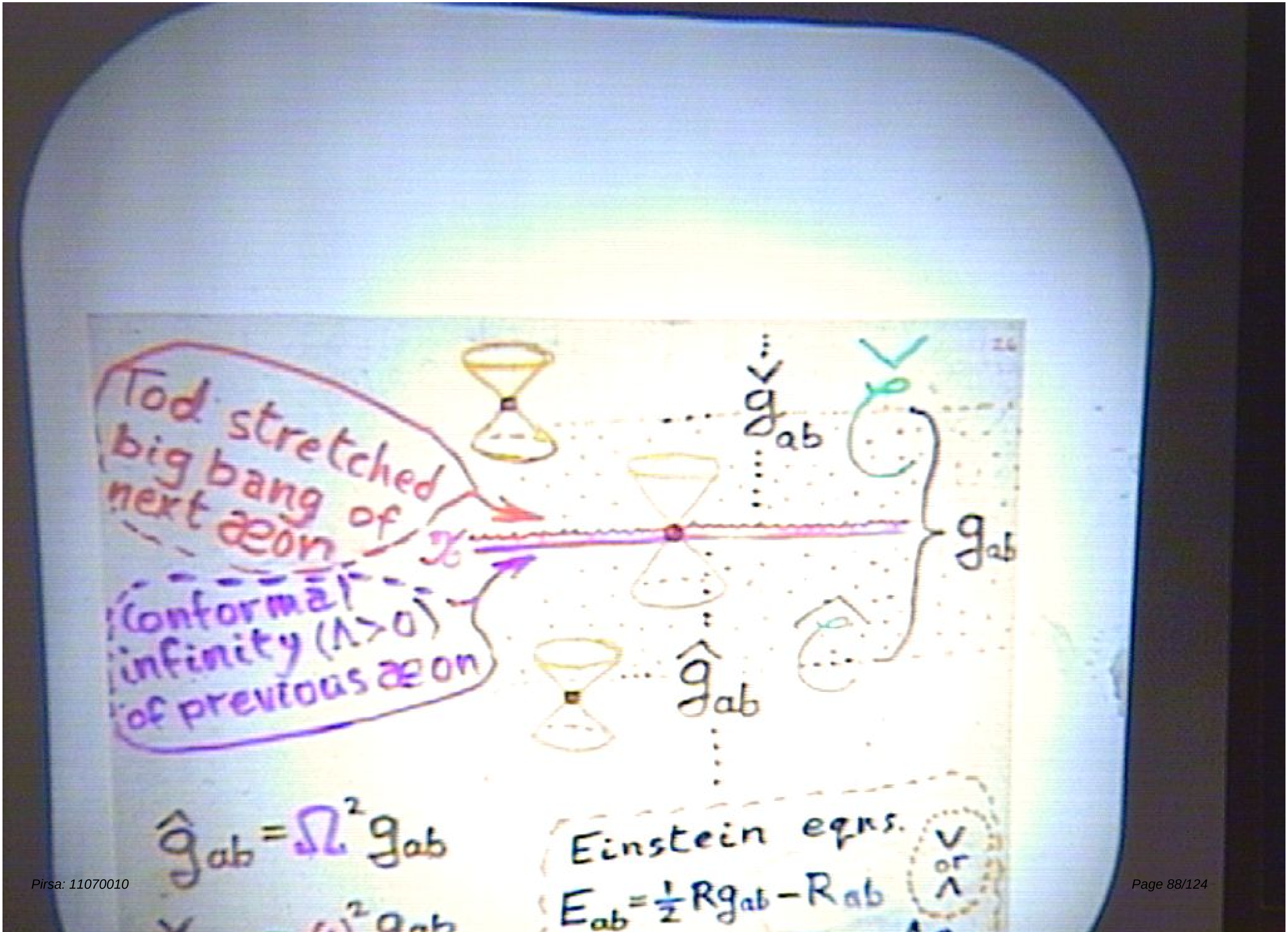
The 1-form

$$\Pi = \frac{d\Omega}{\Omega^2-1} = \frac{d\omega}{1-\omega^2}$$

seems important. It remains smooth across $\mathcal{X}$ and is intimately related to the reciprocal proposal

$\Pi = d\omega$ ...


Tod stretched big bang of next æon
conformal infinity (Λ>0) of previous æon
ǧab
𝒳
gab
ĝab
ĝab = Ω² gab
Einstein eqns.
Eab = ½ R gab − Rab
or



Tod stretched big bang of next æon
conformal infinity ($\Lambda>0$) of previous æon
$\mathscr{I}$
$\check{g}_{ab}$
g_{ab}
$\hat{g}_{ab}$
$\hat{g}_{ab}=\Omega^2 g_{ab}$
Einstein eqns.
$E_{ab}=\frac{1}{2}Rg_{ab}-R_{ab}$
$\vee$ or $\wedge$

total energy tensor in $\hat{\mathcal{E}}$

$$\check{U}_{ab} = \check{T}_{ab} + \check{V}_{ab} + \check{W}_{ab}$$

Total

massless fields from $\hat{\mathcal{E}}$

energy tensor of phantom fld. become real

remaining piece, which has the trace μ

We find:

$$\mu = \frac{(\Omega^2-1)}{2\pi G}\{3\Pi^a\Pi_a - \Delta\}$$

The 1-form

$$\Pi = \frac{d\Omega}{\Omega^2-1} = \frac{d\omega}{1-\omega^2}$$

seems important. It remains smooth across $\mathscr{X}$ and is intimately related to the reciprocal proposal. Note:

$$\Pi = d\tau, \quad -\coth\tau = \Omega, \quad \tanh\tau = \omega$$

$(\tau < 0)$ $(\tau > 0)$

τ is a useful "time" parameter

s rest-mass contribution

total energy tensor in $\check{\mathcal{C}}$

$$\check{U}_{ab} = \check{T}_{ab} + \check{V}_{ab} + \check{W}_{ab}$$

Total

massless fields from $\hat{\mathcal{C}}$

energy tensor of phantom fld. become real

remaining piece, which has the trace μ

We find:

$$\mu = \frac{(\Omega^2-1)}{2\pi G}\{3\Pi^a\Pi_a - \Lambda\}$$

The 1-form

$$\Pi = \frac{d\Omega}{\Omega^2-1} = \frac{d\omega}{1-\omega^2}$$

seems important. It remains smooth across $\mathcal{X}$ and is intimately related to the reciprocal proposal. Note:

$$\Pi = d\tau, \quad -\coth\tau = \Omega, \quad \tanh\tau = \omega$$

$(\tau<0)$ $(\tau>0)$

τ is a useful "time" parametactor ω (or, equivalent

This fixing would app

be satisfactorily

if we can force ω

2 scalar condition

(since it sat's a 2nd order eq

My guess for best bet is:

$$3\Pi^a\Pi_a - \Lambda = O(\omega^3)$$

Since this delays the growing of rest mass for as long as possible, so it is most in keeping with the CCC ph factor ω (or, equivalently $\Omega = -\omega^{-1}$)

This fixing would appear to be satisfactorily achieved if we can force ω to satisfy 2 scalar conditions over $\mathscr{X}$ (since it sat's a 2^{nd}-order eqn).

My guess for best bet is:

$$3\Pi^a\Pi_a - \Lambda = O(\omega^3)$$

Since this delays the growing of rest mass for as long as possible, so it is most in keeping with the CCC philosophy factor ω (or, equivalently $\Omega = -\omega^{-1}$)

This fixing would appear to be satisfactorily achieved if we can force ω to satisfy 2 scalar conditions over $\mathscr{X}_0$ (since it sat's a 2nd-order eqn).

My guess for best bet is:

$$3\Pi^a\Pi_a - \Lambda = O(\omega^3)$$

Since this delays the growing of rest mass for as long as possible, so it is most in keeping with the CCC philosophy

... the trace $U_a^{\ a} = 4\Lambda$

... instead we find that there is a rest-mass contribution to the total energy tensor in $\check{\mathscr{C}}$

$$\check{U}_{ab} = \check{T}_{ab} + \check{V}_{ab} + \check{W}_{ab}$$

Total

massless fields from $\hat{\mathscr{C}}$

energy tensor of phantom fld. become real

remaining piece, which has the trace μ

We find:

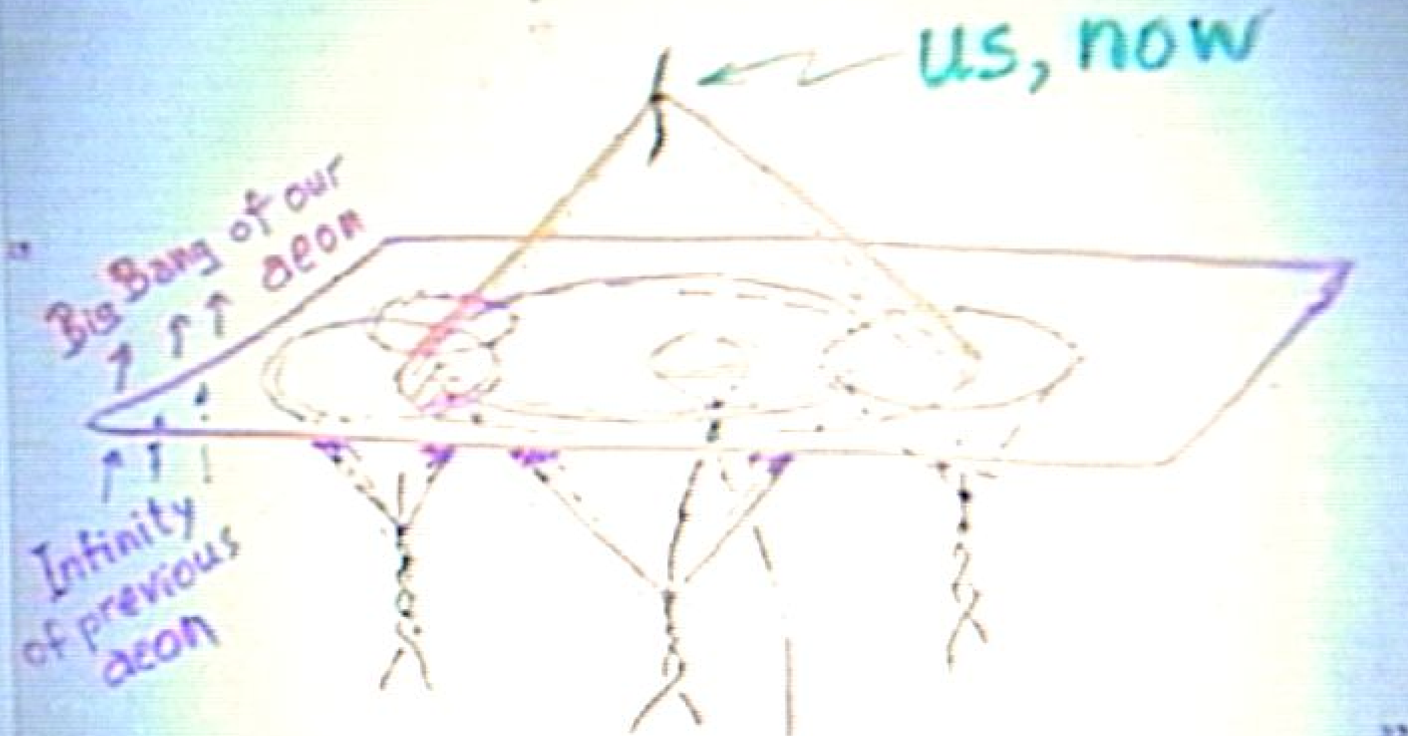
$$\mu = \frac{(\Omega^2-1)}{2\pi G}\left\{3\Pi^a\Pi_a - \Lambda\right\}$$

The 1-form

$$\Pi = \frac{d\Omega}{\Omega^2-1} = \frac{d\omega}{1-\omega^2}$$

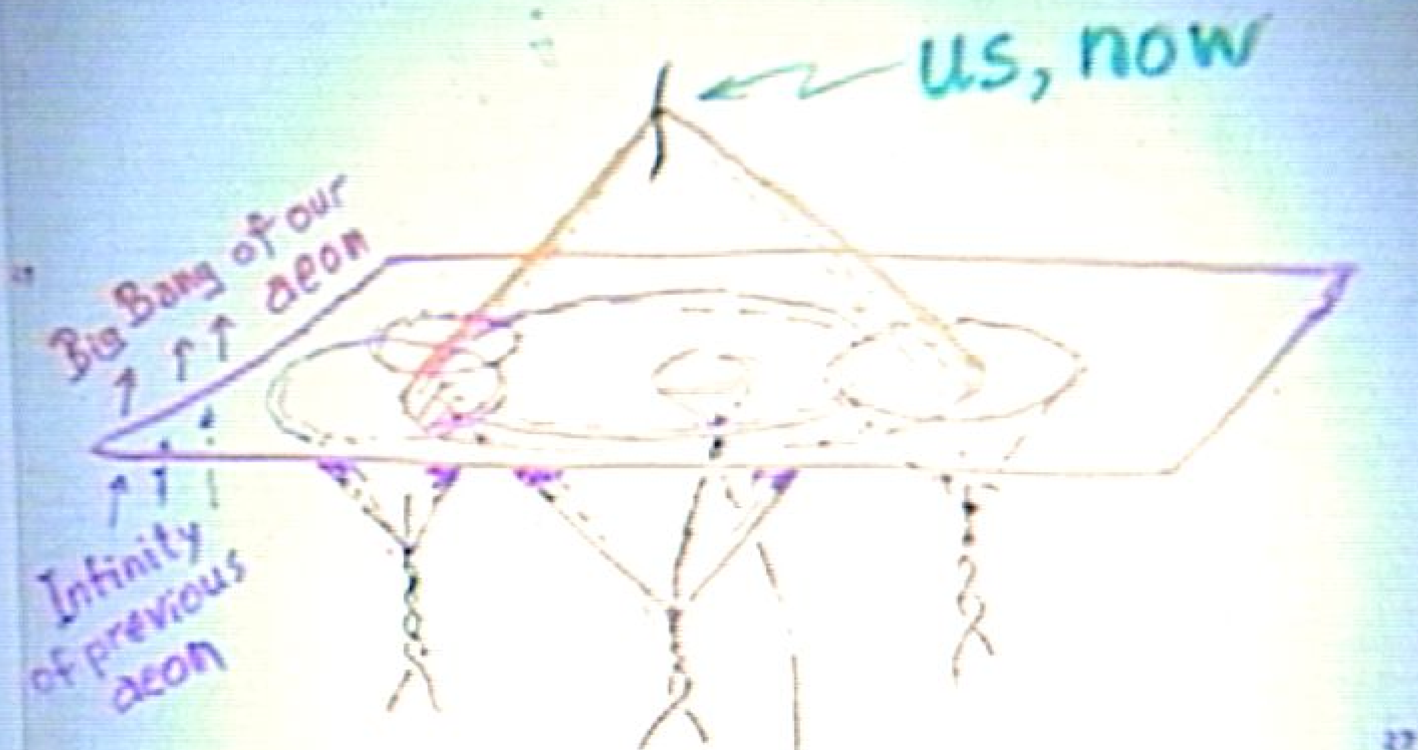
seems important. It remains smooth across $\mathscr{X}$ and is intimately related

Observational consequence concerning temperature/density variations in Cosmic Microwave Background



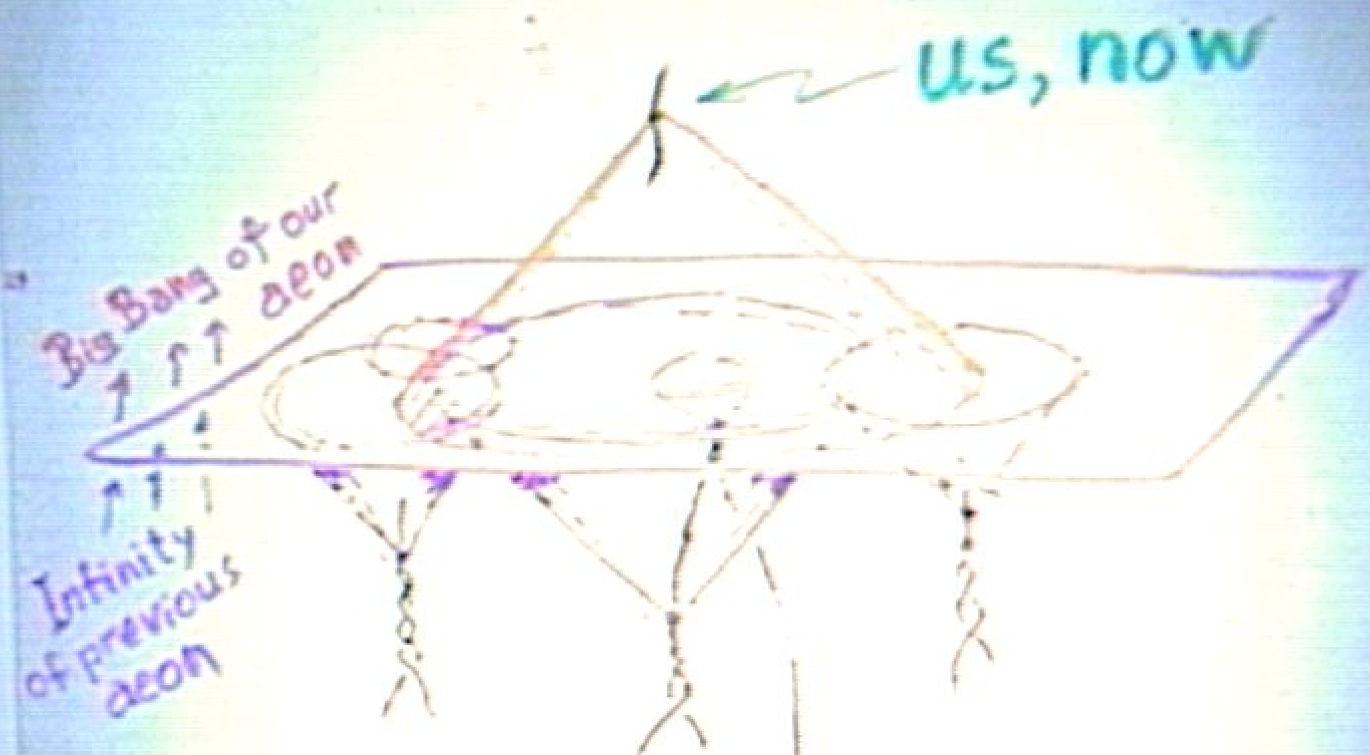
-Think of ripples on a pond, caused by raindrops which have recently stopped falling.
Pattern of

Observational Conse...
concerning temperature/density variations in Cosmic Microwave Background

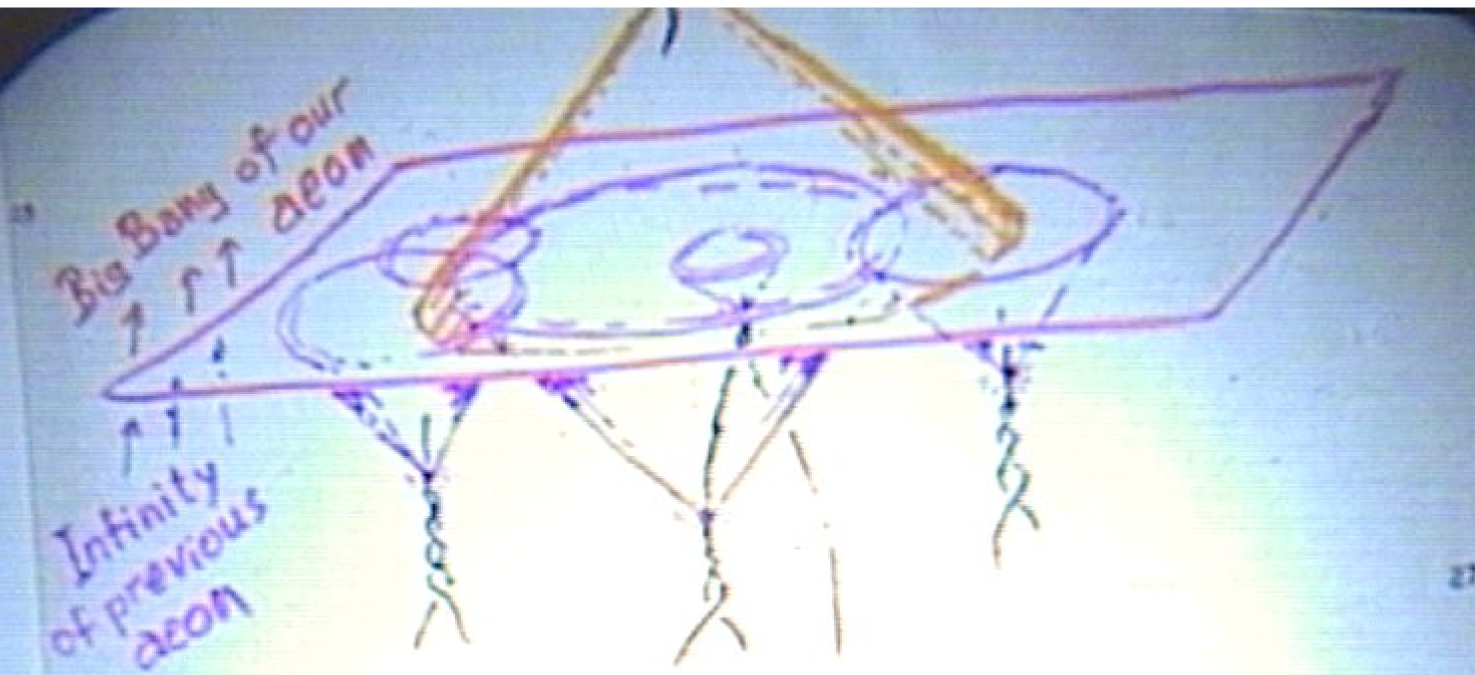


Think of ripples on a pond, caused by raindrops which have recently stopped falling.
Pattern of ripples
looks rand...

Observational consequence concerning temperature/density variations in Cosmic Microwave Background

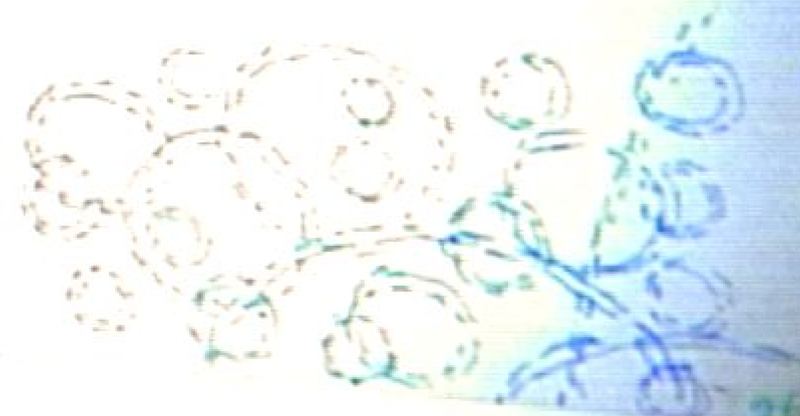


. Think of ripples on a pond, caused by raindrops which have recently stopped falling.
Pattern of ripple...

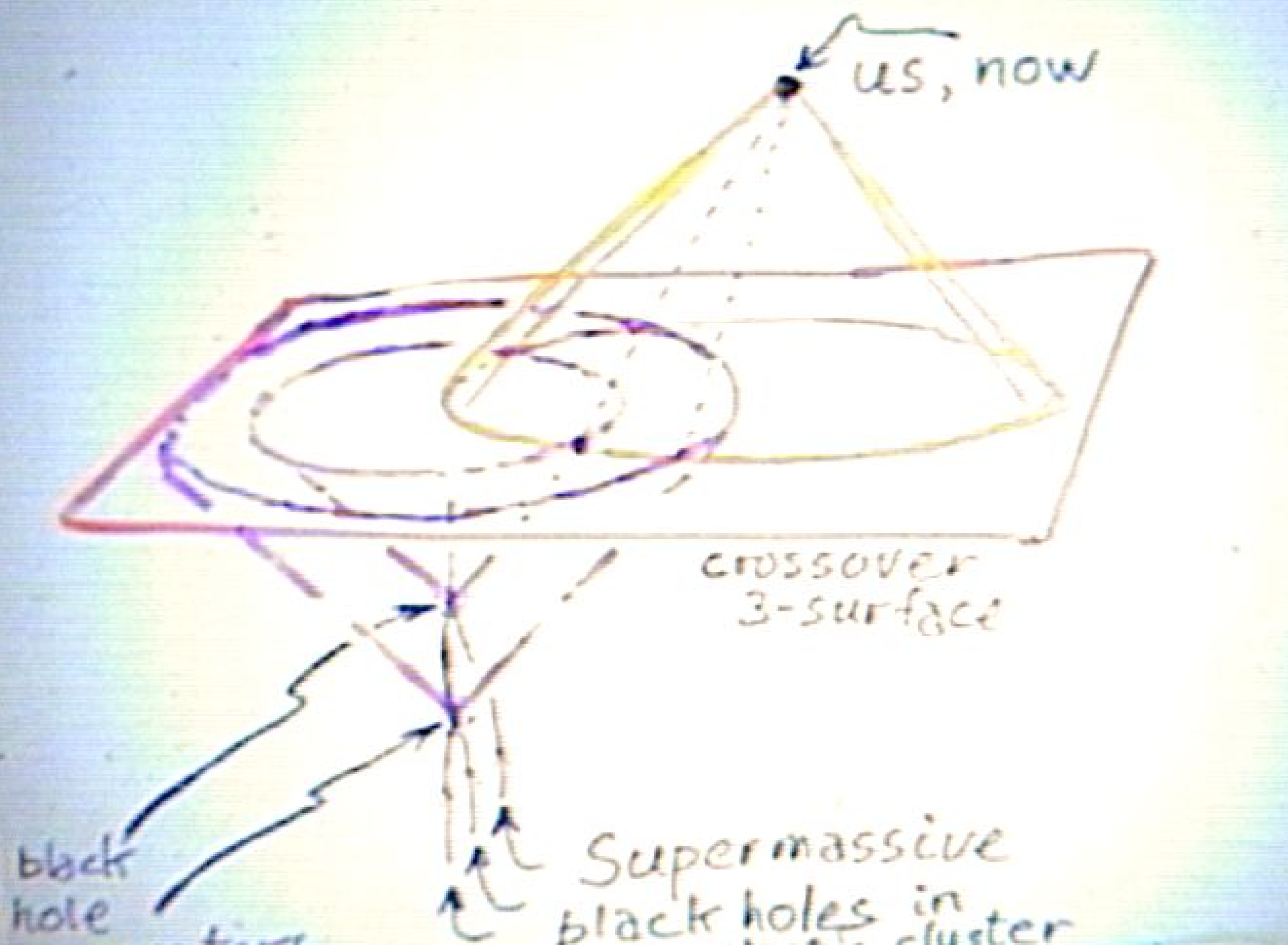


Think of ripples on a pond, caused by raindrops which have recently stopped falling.

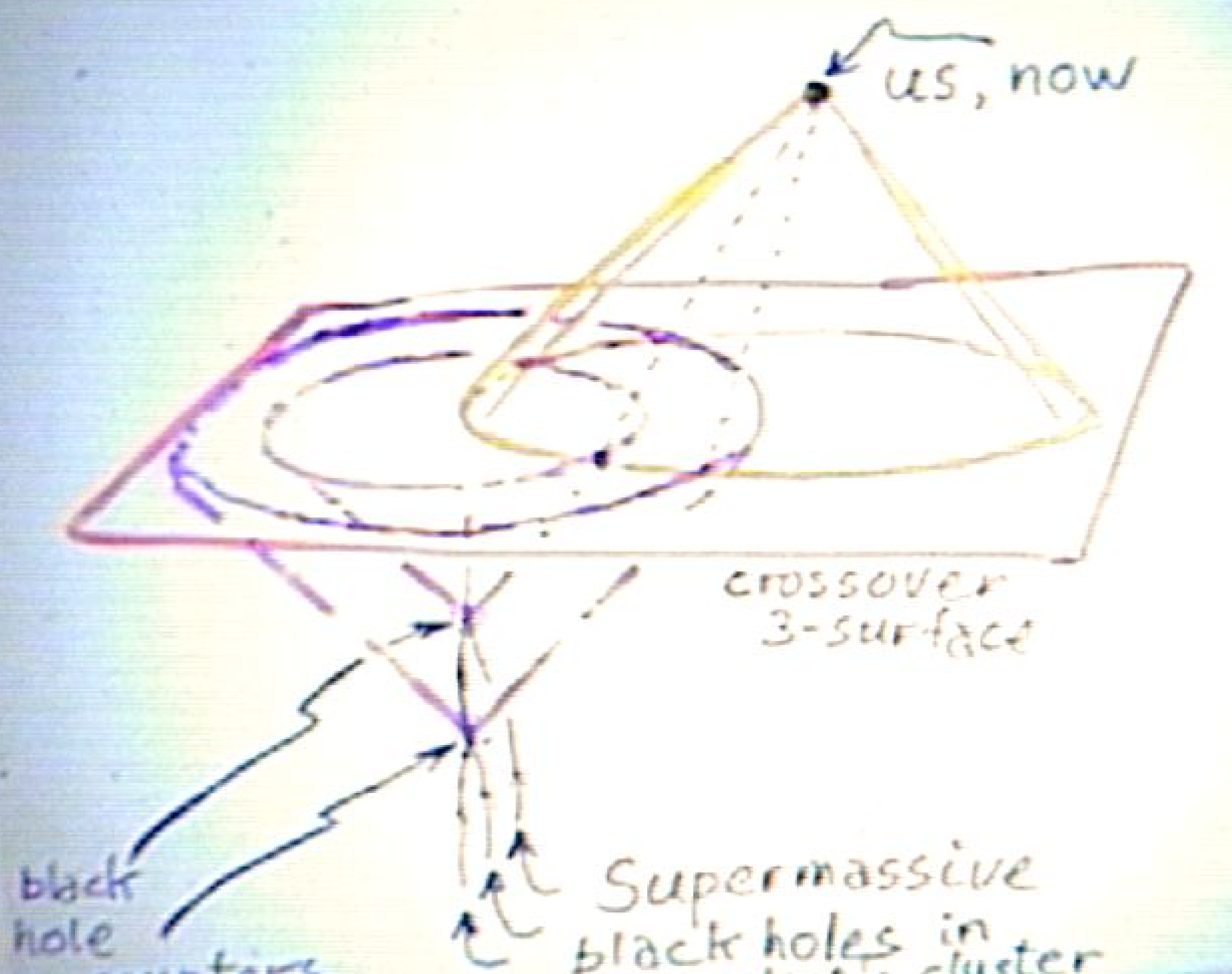
Pattern of ripples looks random at first, but can be analysed into circles by statistical analysis.



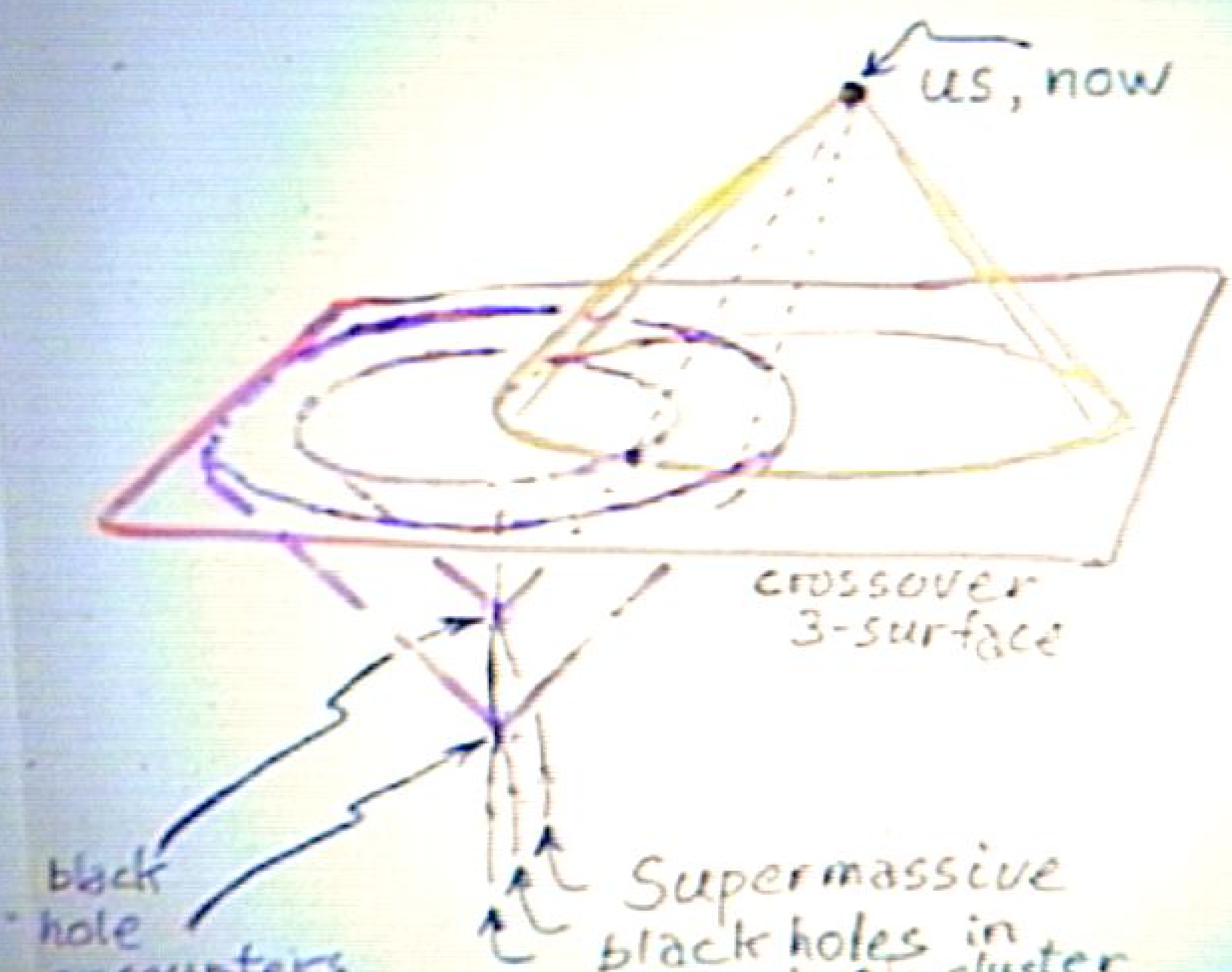
Can we "see" through into the aeon prior to ours?

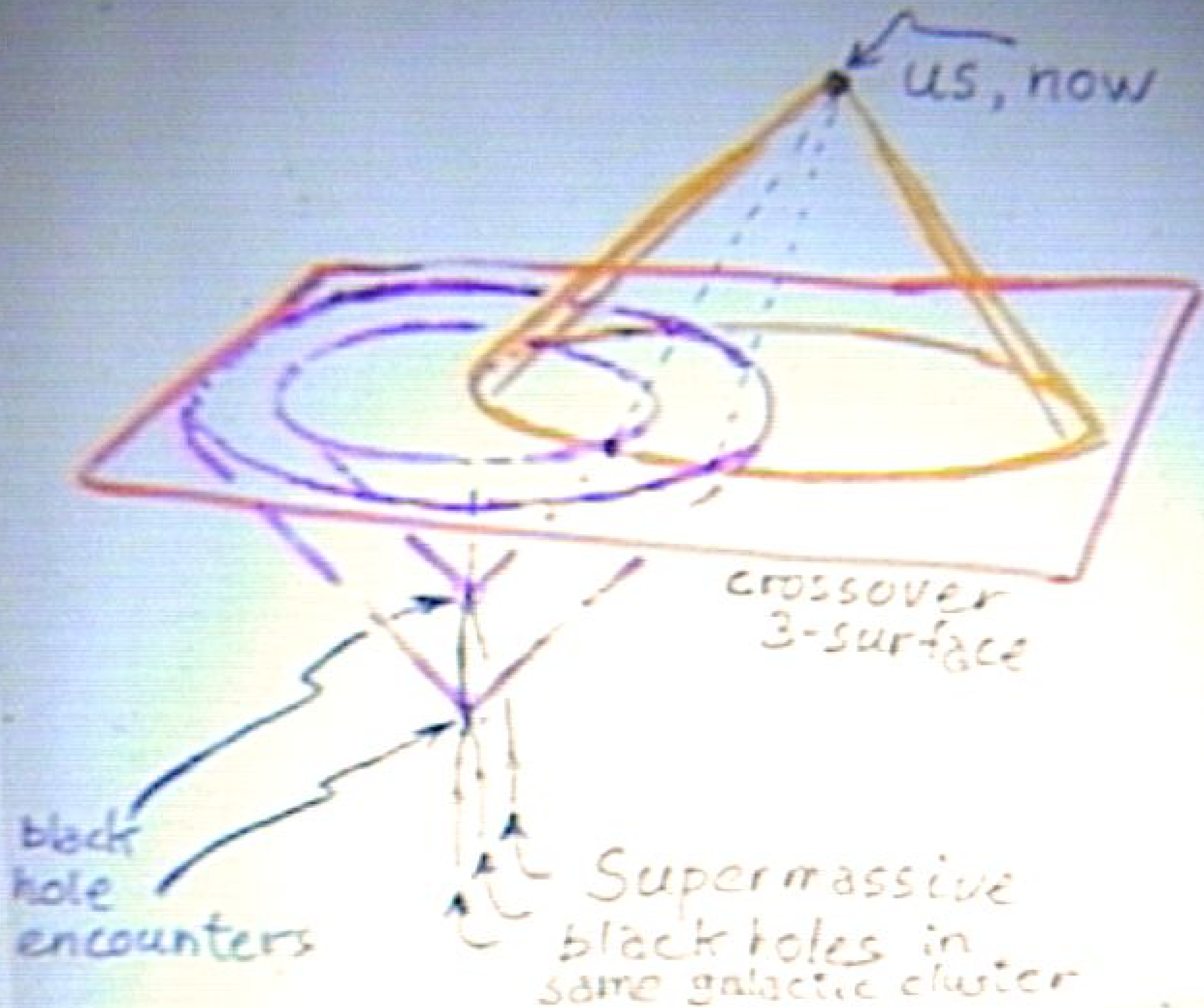


Can we "see" through into the aeon prior to ours?



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

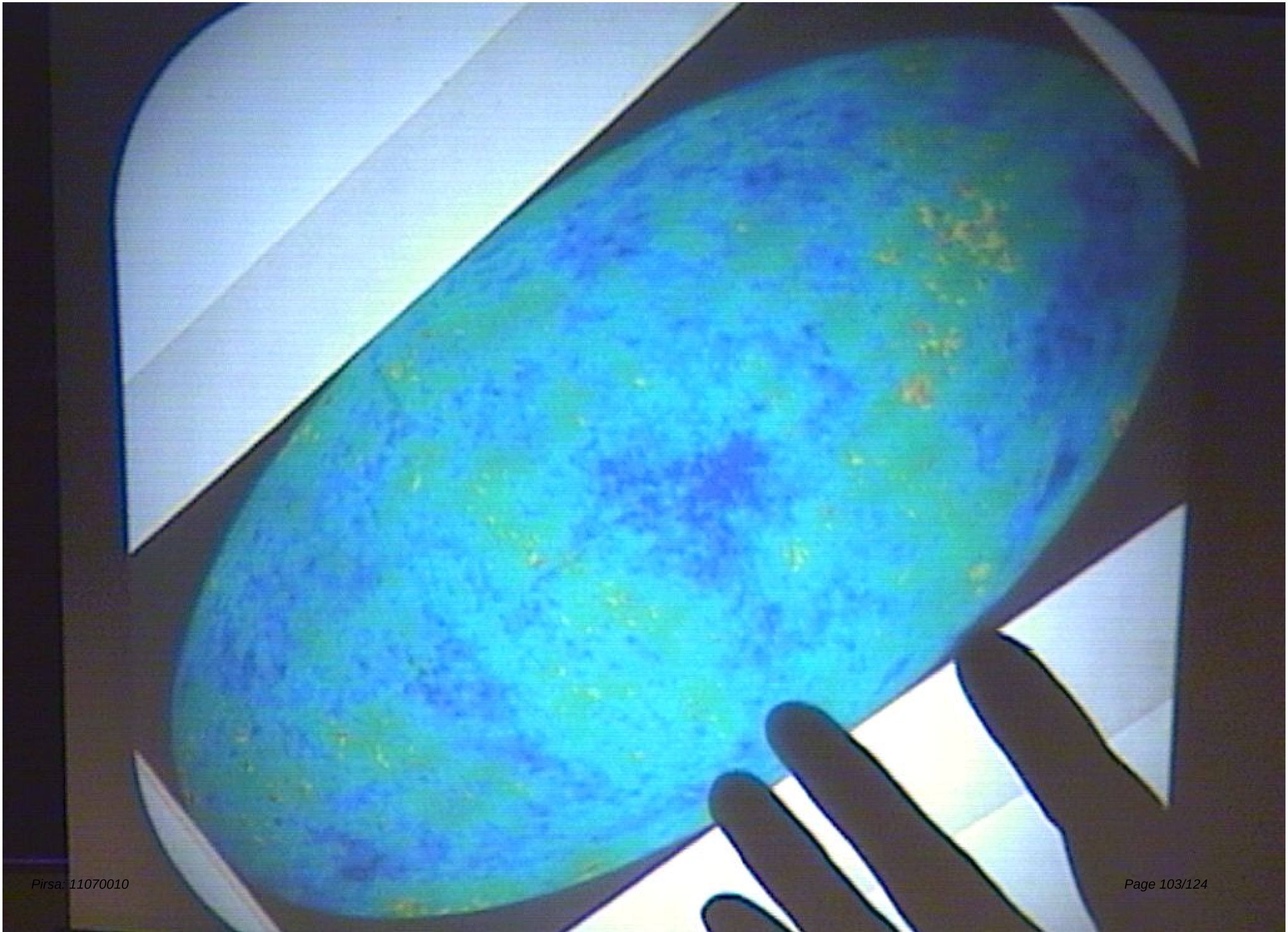


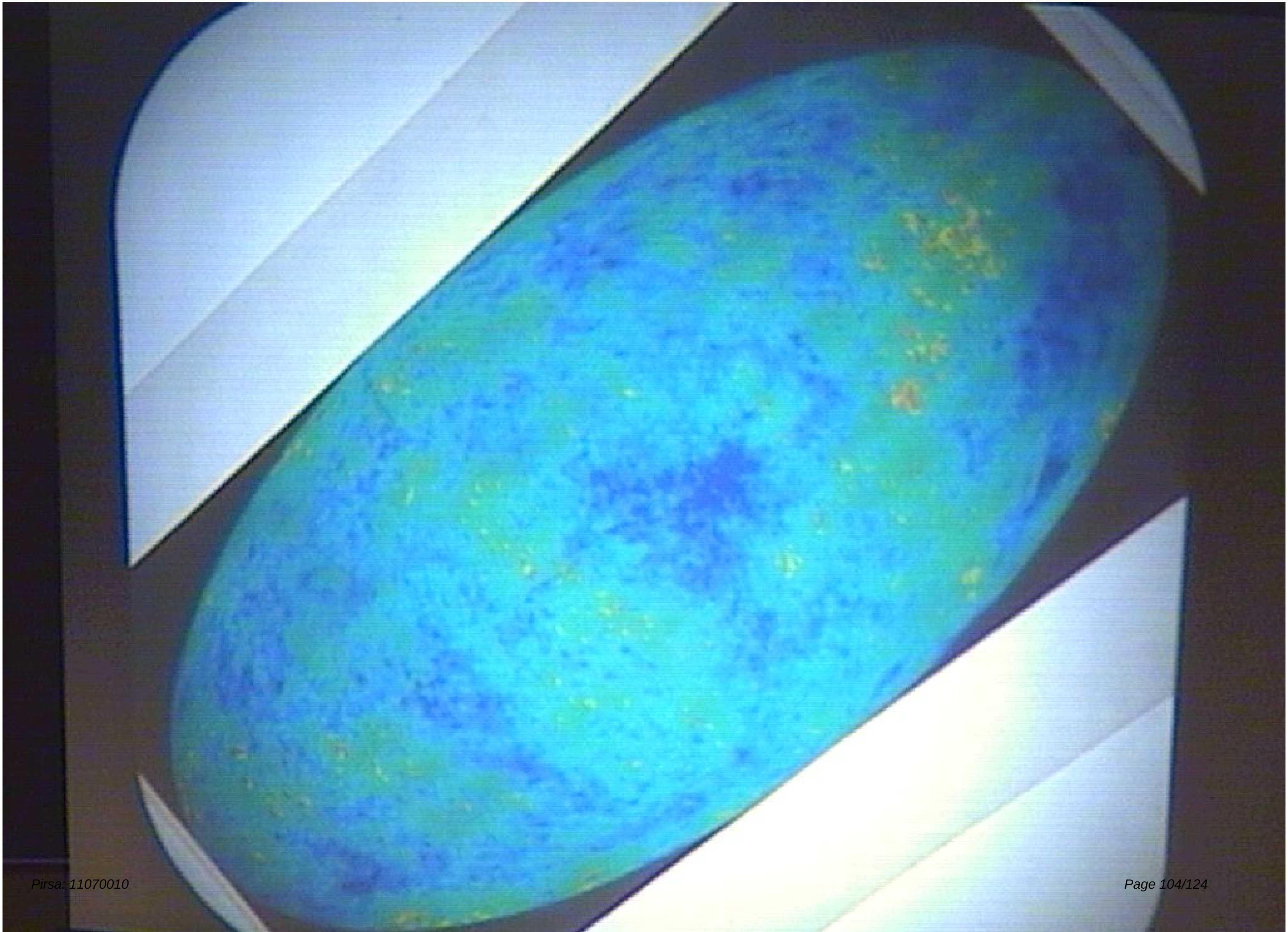


noteworthy

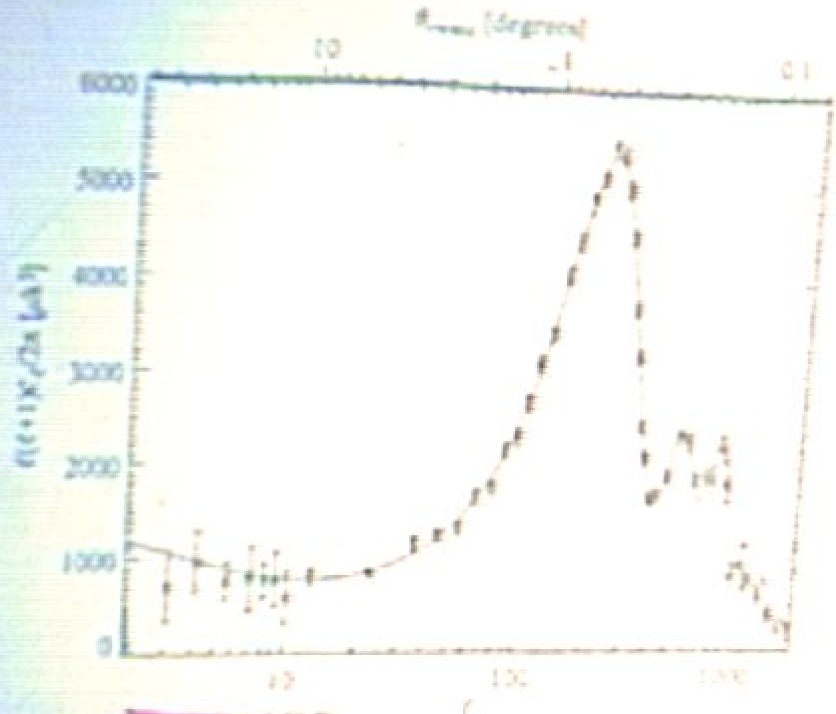
- temperature

- low variance

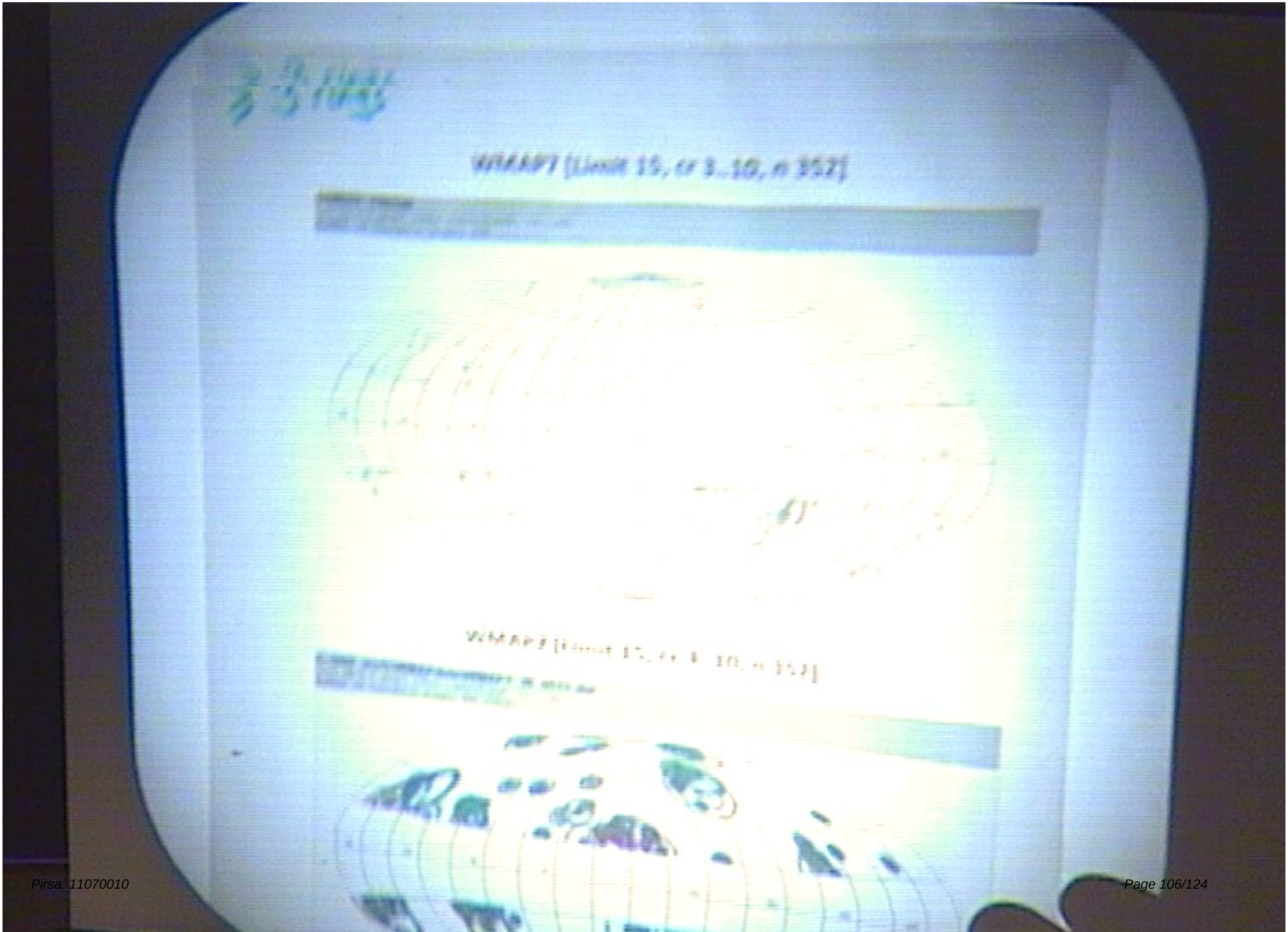




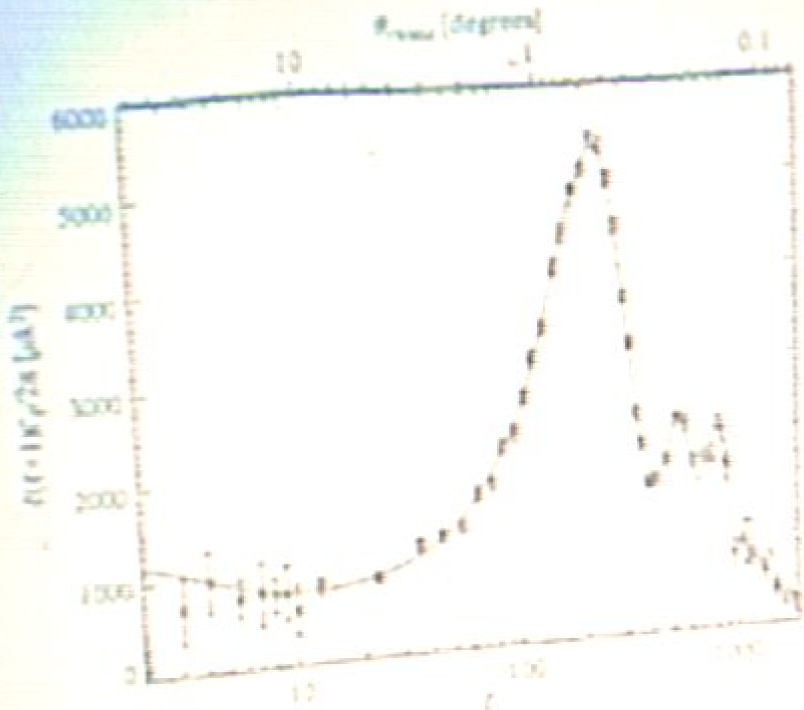
CMB power spectrum



ℓ-values, in harmonic (ℓ, m)-

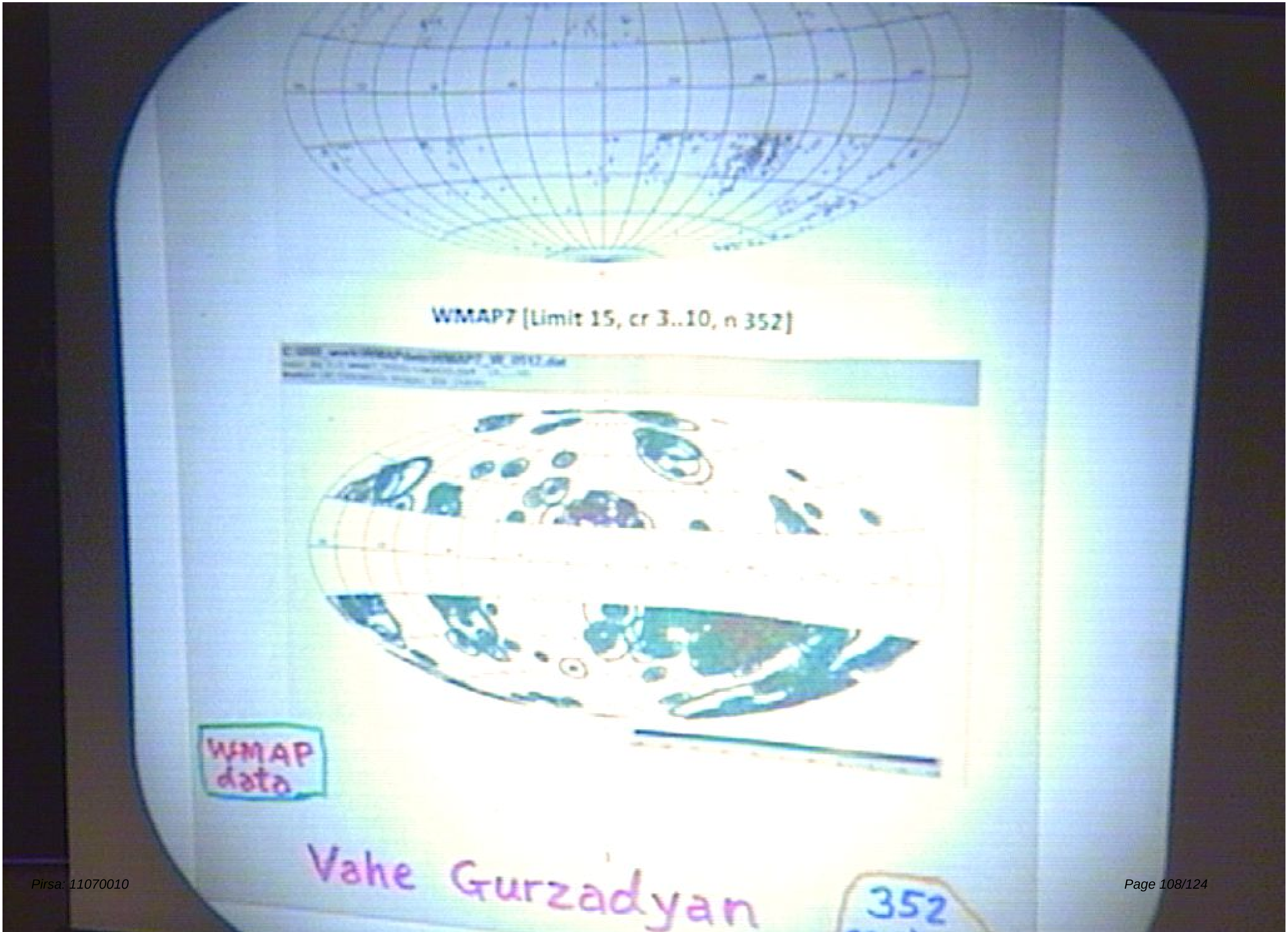


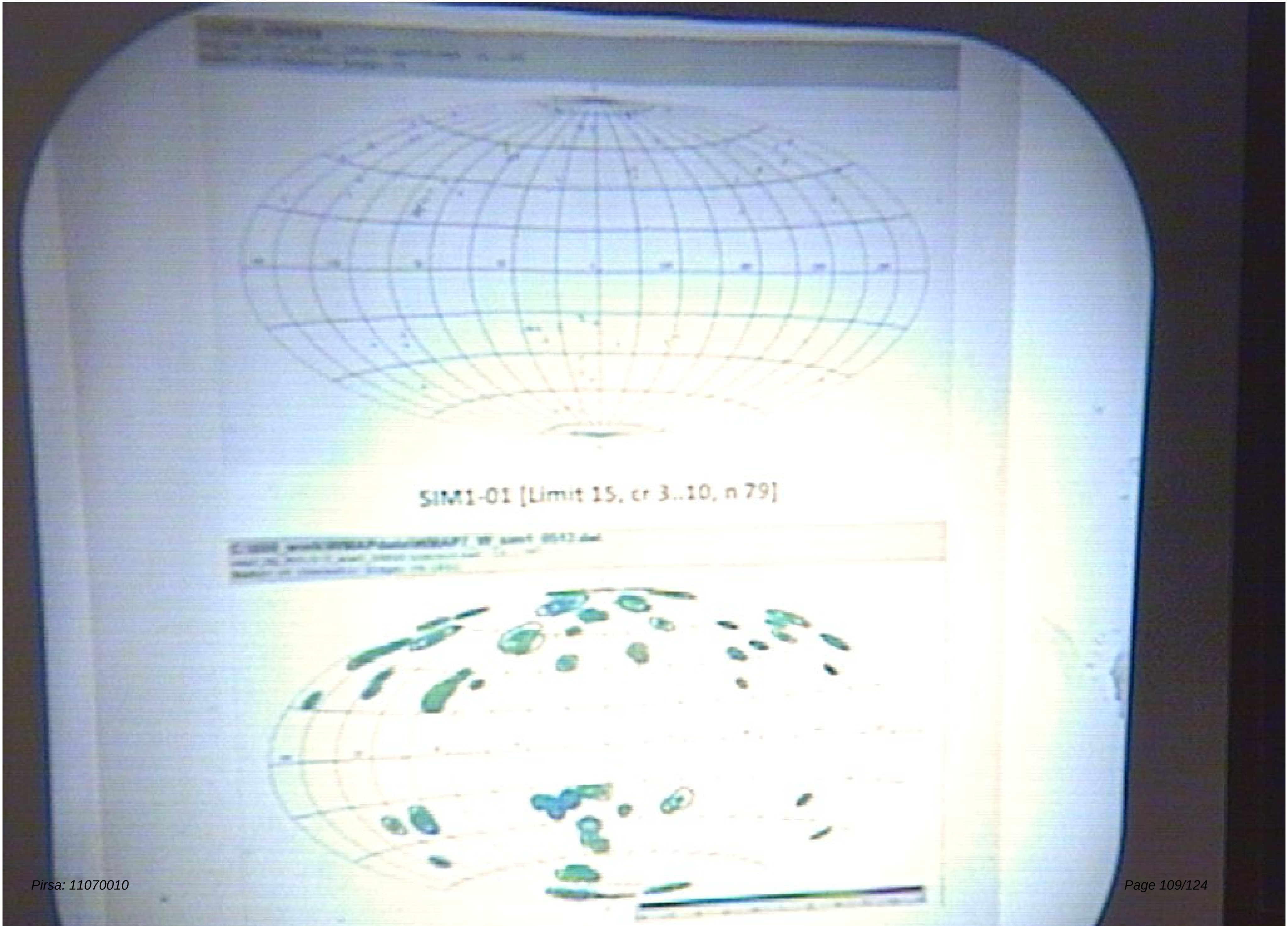
CMB power spectrum

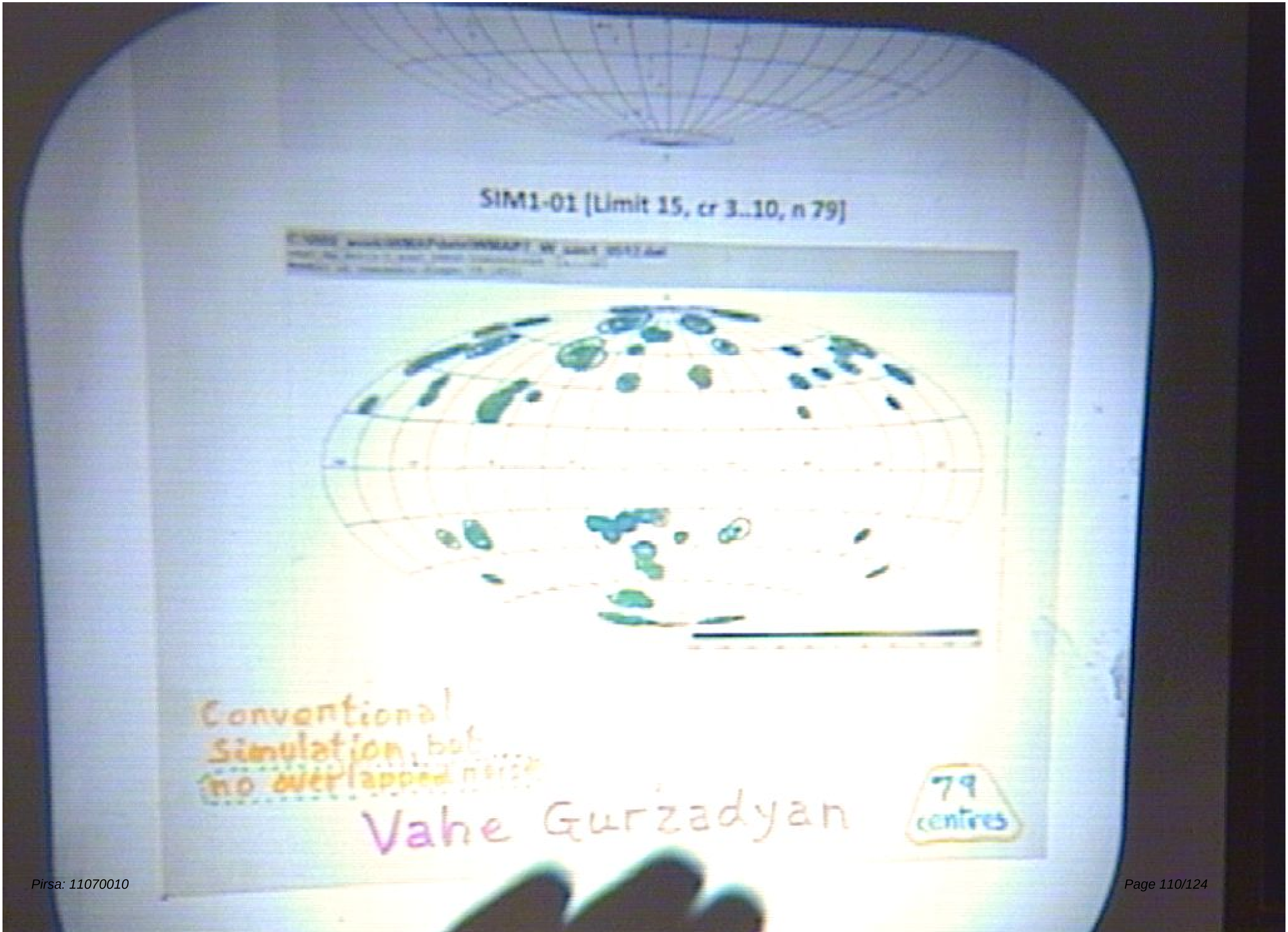


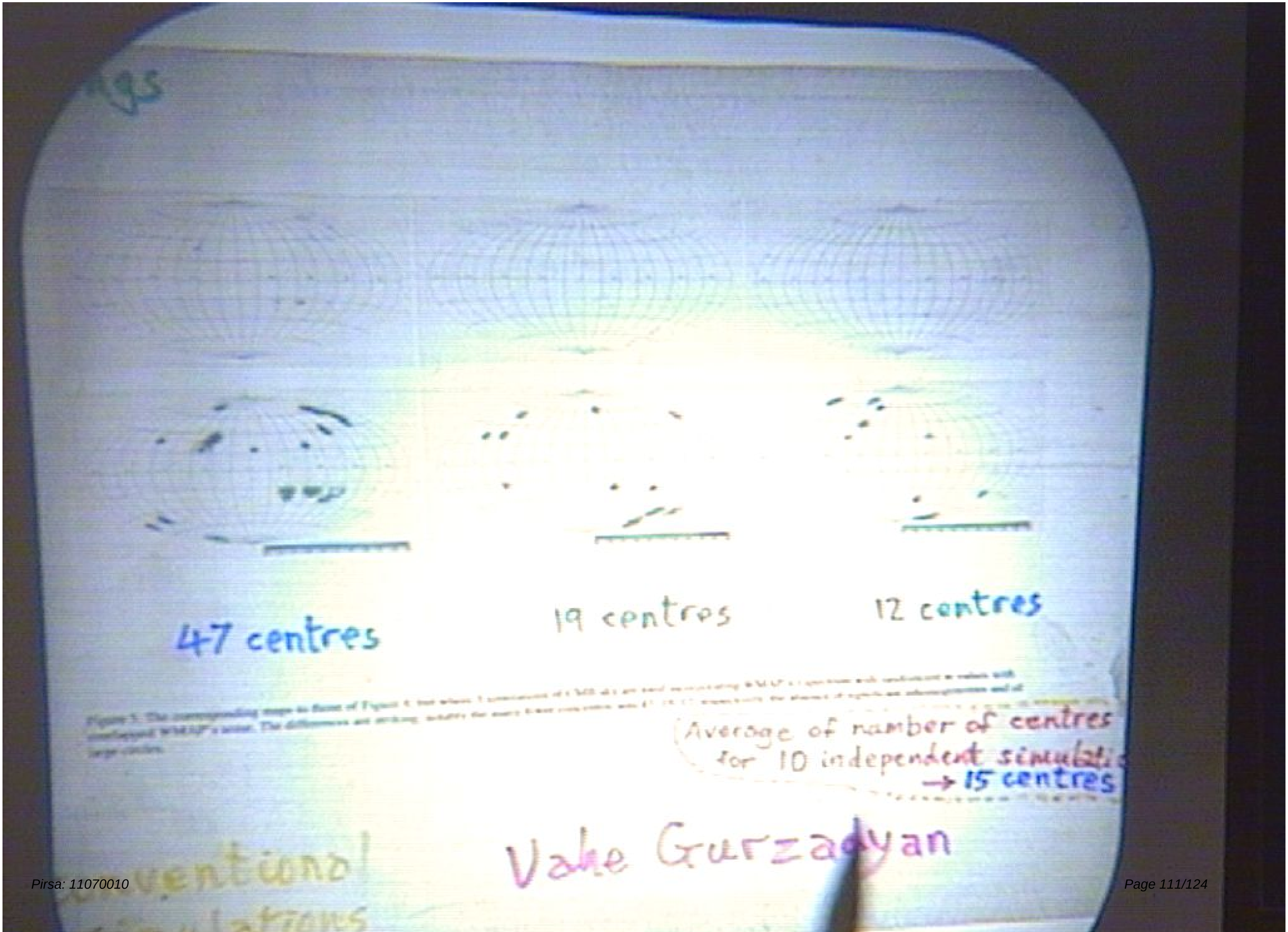
ℓ-values, in harmonic (ℓ, m)-

of CMB temperatures

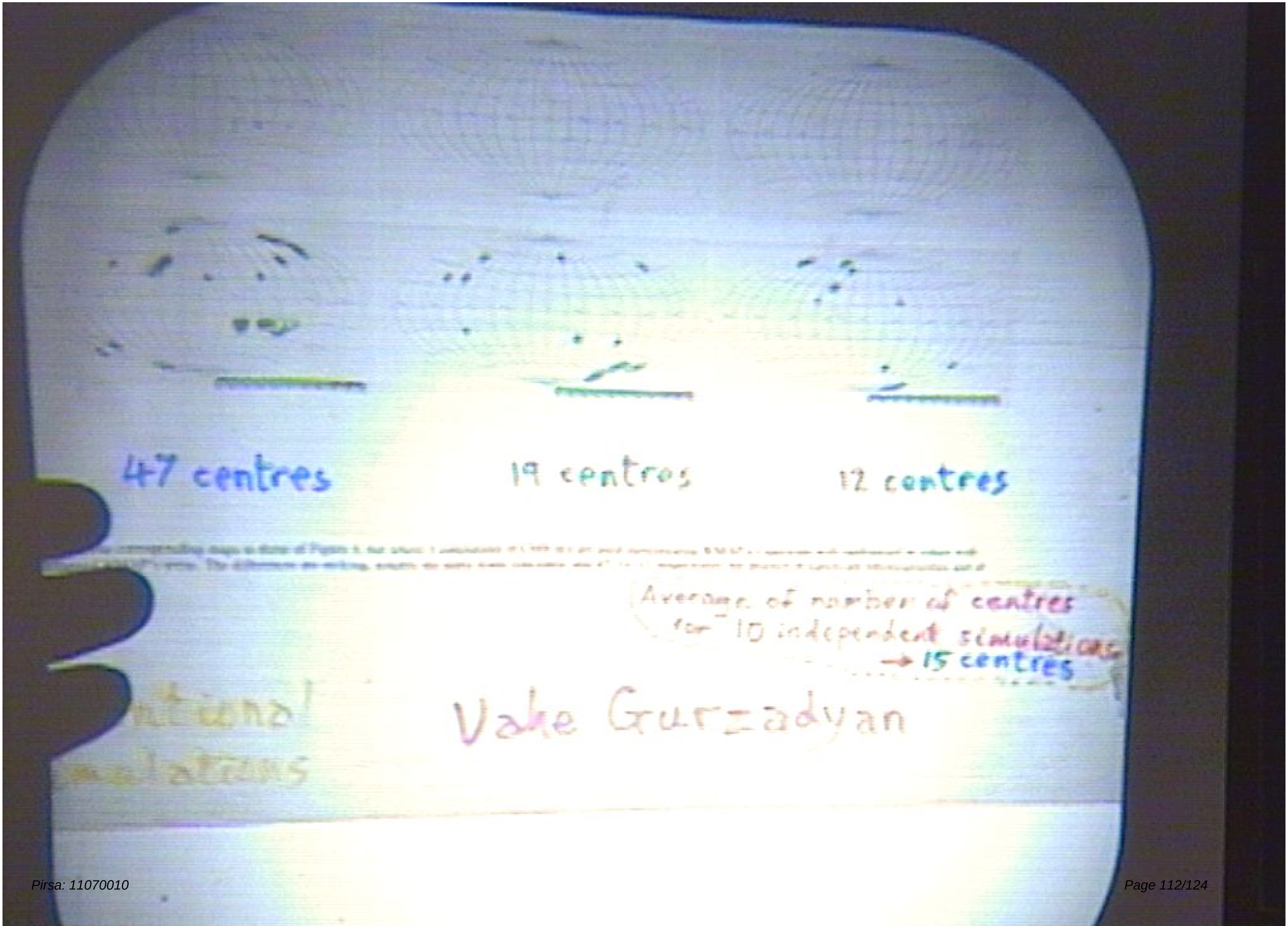

WMAP7 [Limit 15, cr 3..10, n 352]
WMAP data
Vahe Gurzadyan
352

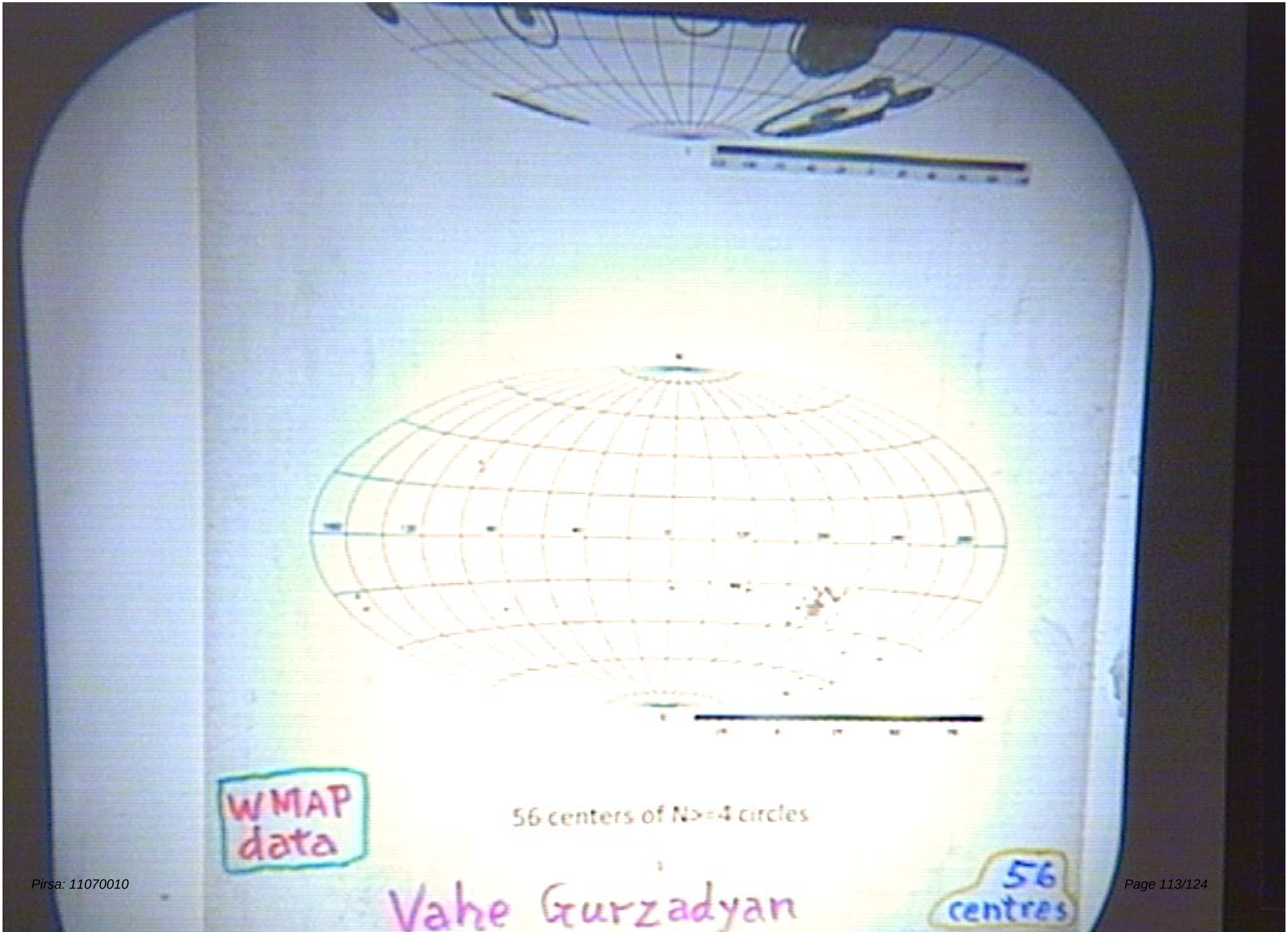

SIM1-01 [Limit 15, cr 3..10, n 79]

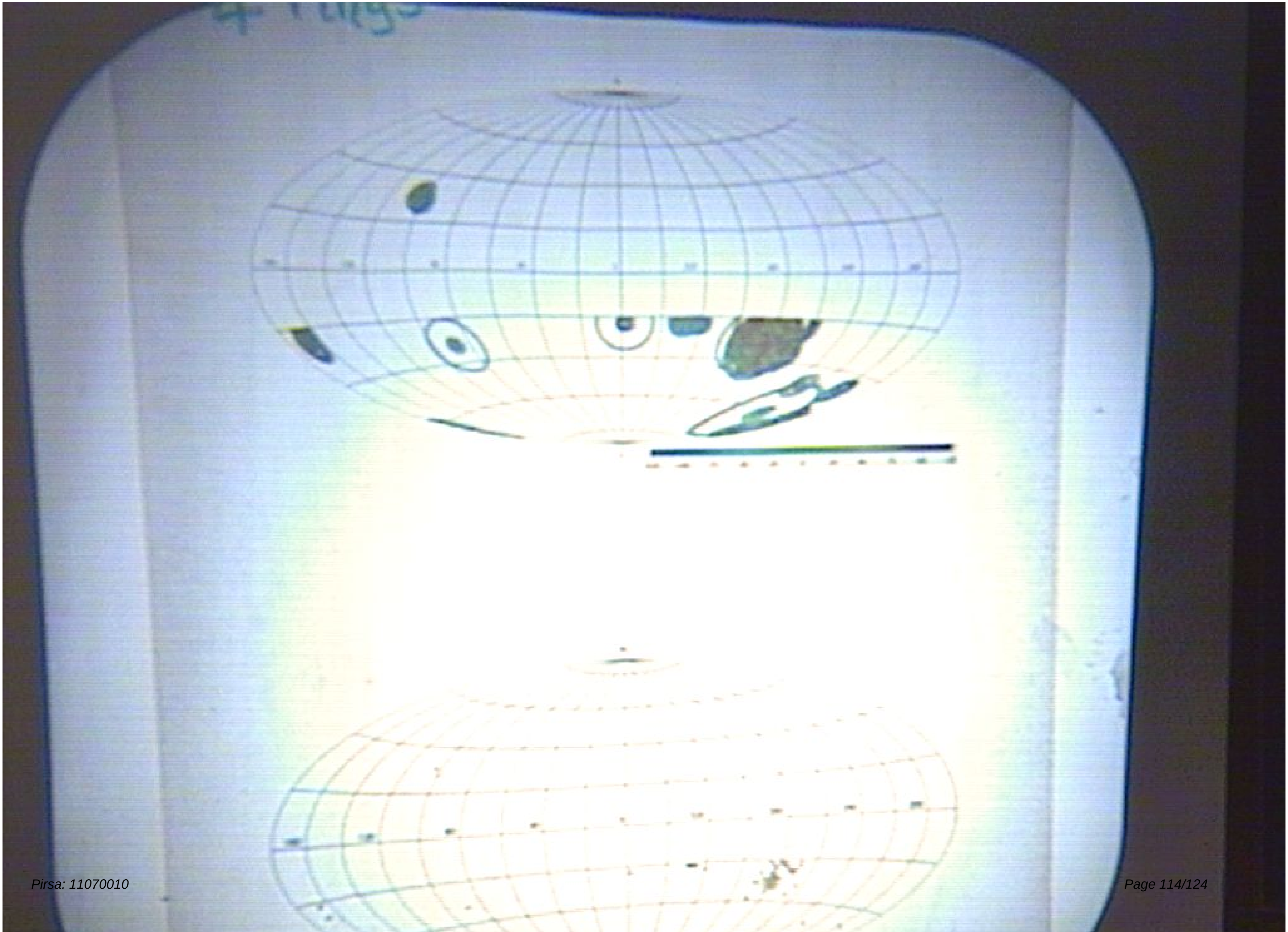

SIM1-01 [Limit 15, cr 3..10, n 79]
Conventional Simulation, but no overlapped noise
Vahe Gurzadyan
79 centres

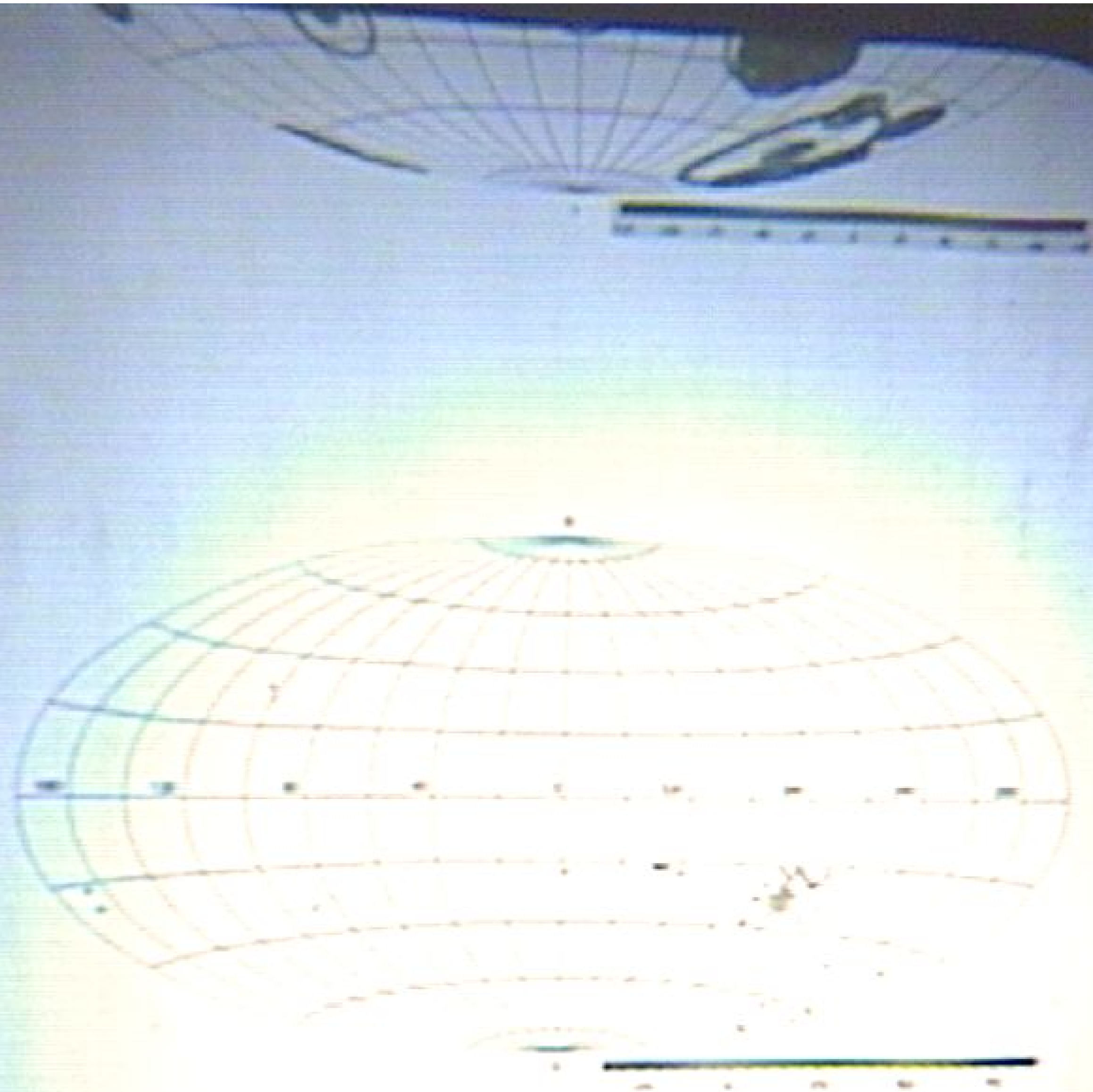


47 centres
19 centres
12 centres
Average of number of centres
for 10 independent simulati
→ 15 centres
Vahe Gurzadyan


47 centres
19 centres
12 centres
Average of number of centres
for 10 independent simulations
→ 15 centres
Vahe Gurzadyan


WMAP data
56 centers of N>=4 circles
56 centres
Vahe Gurzadyan



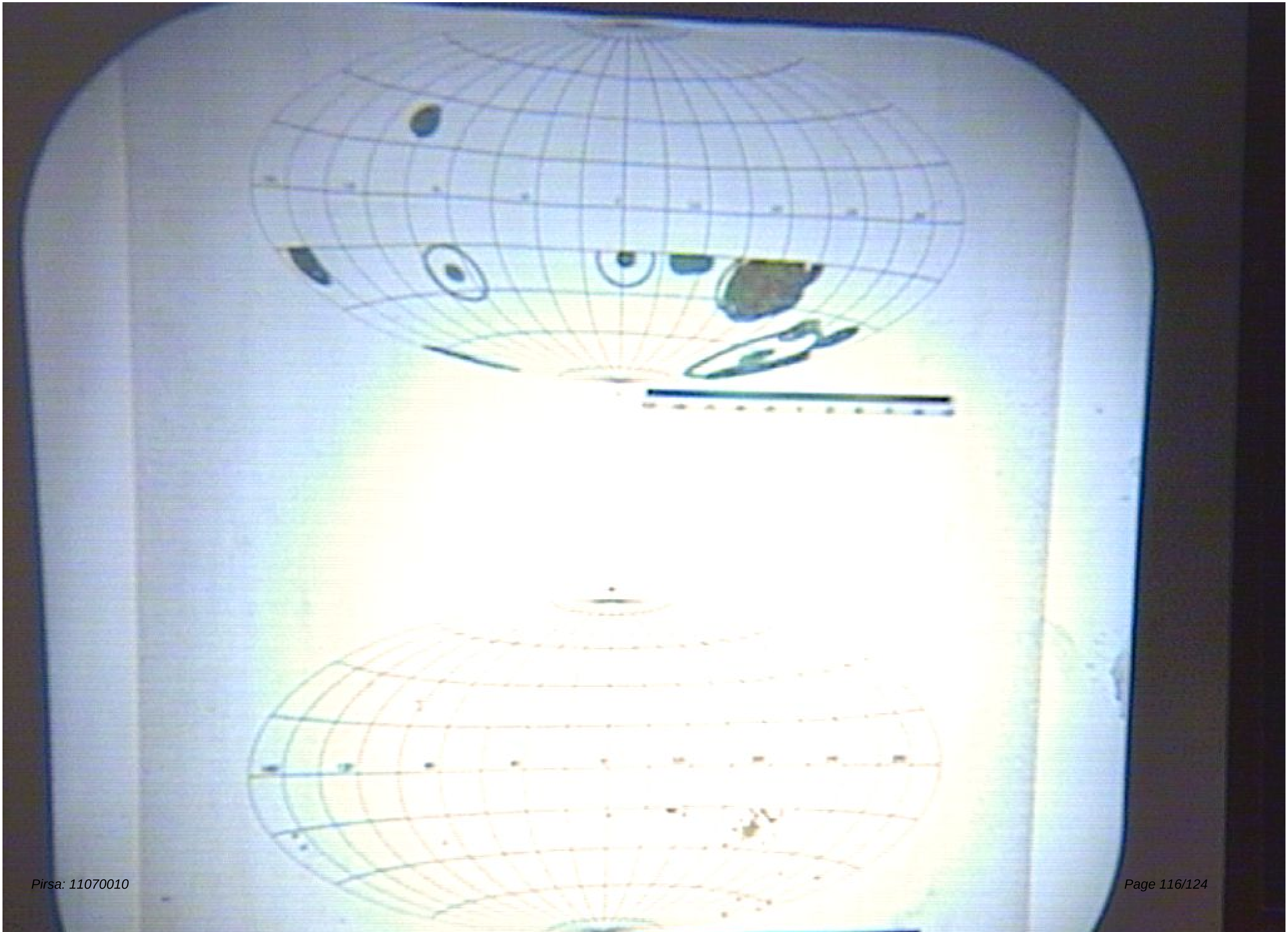


WMAP data

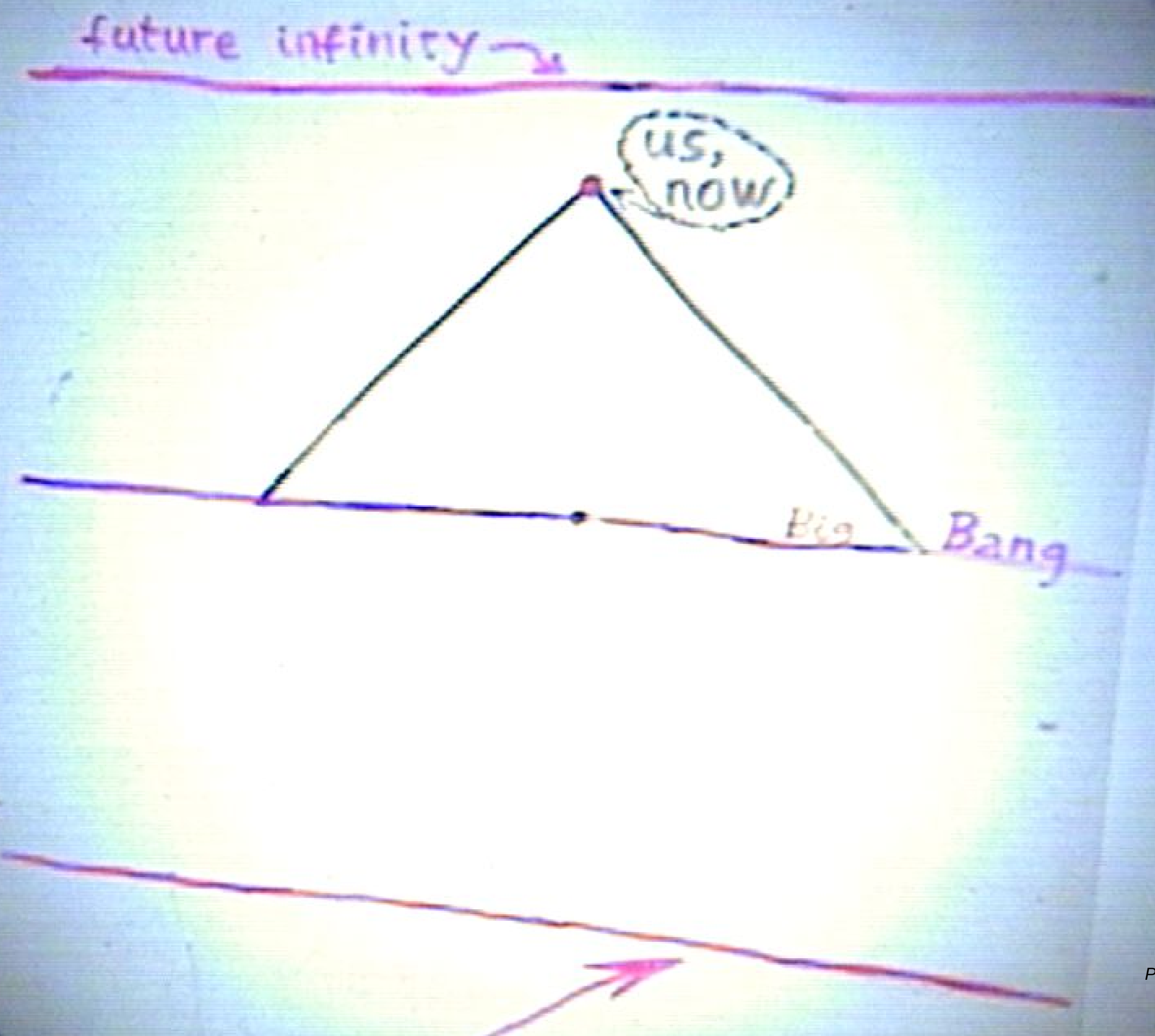
56 centers of N>=4 circles

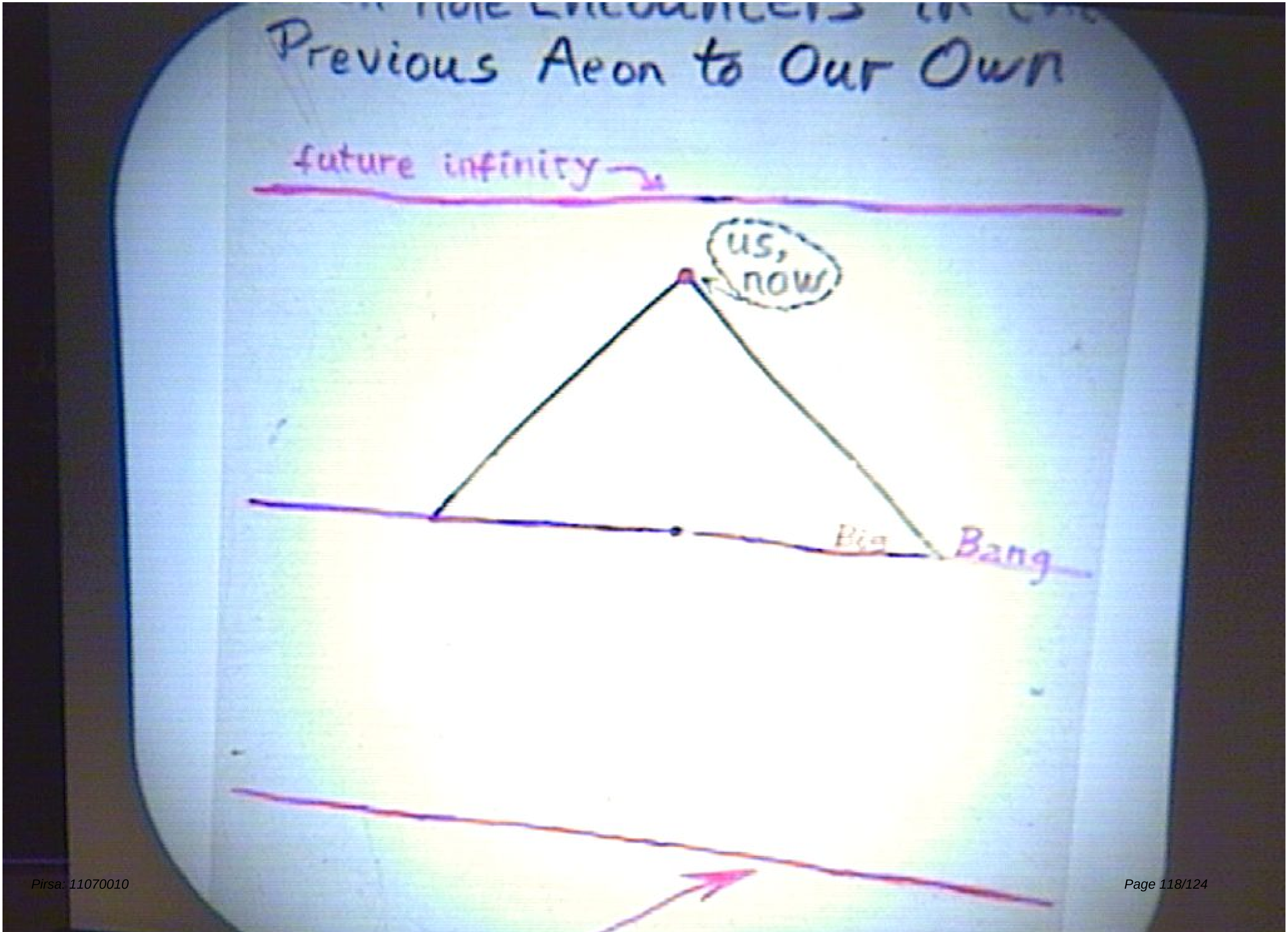
56 centres

Vahe Gurzadyan

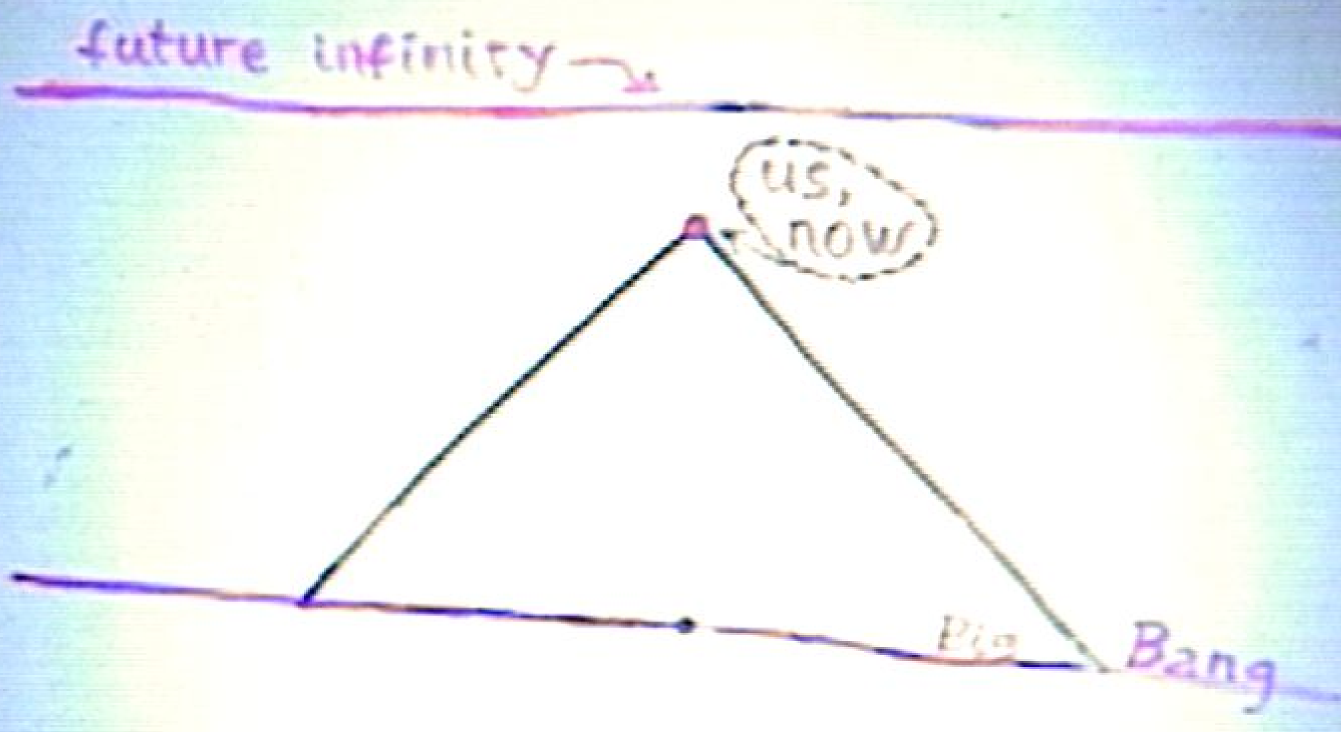


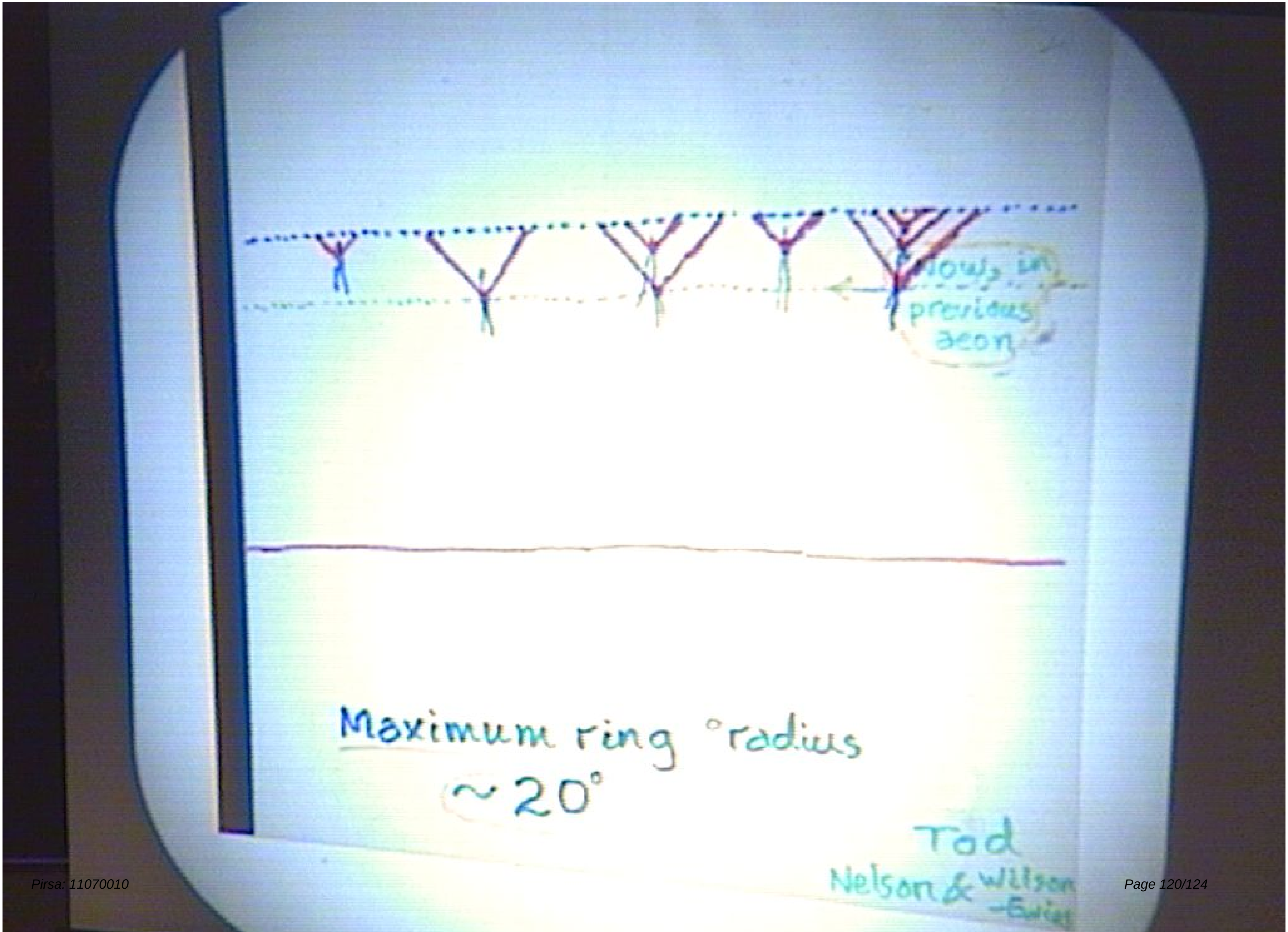
Previous Aeon to Our Own



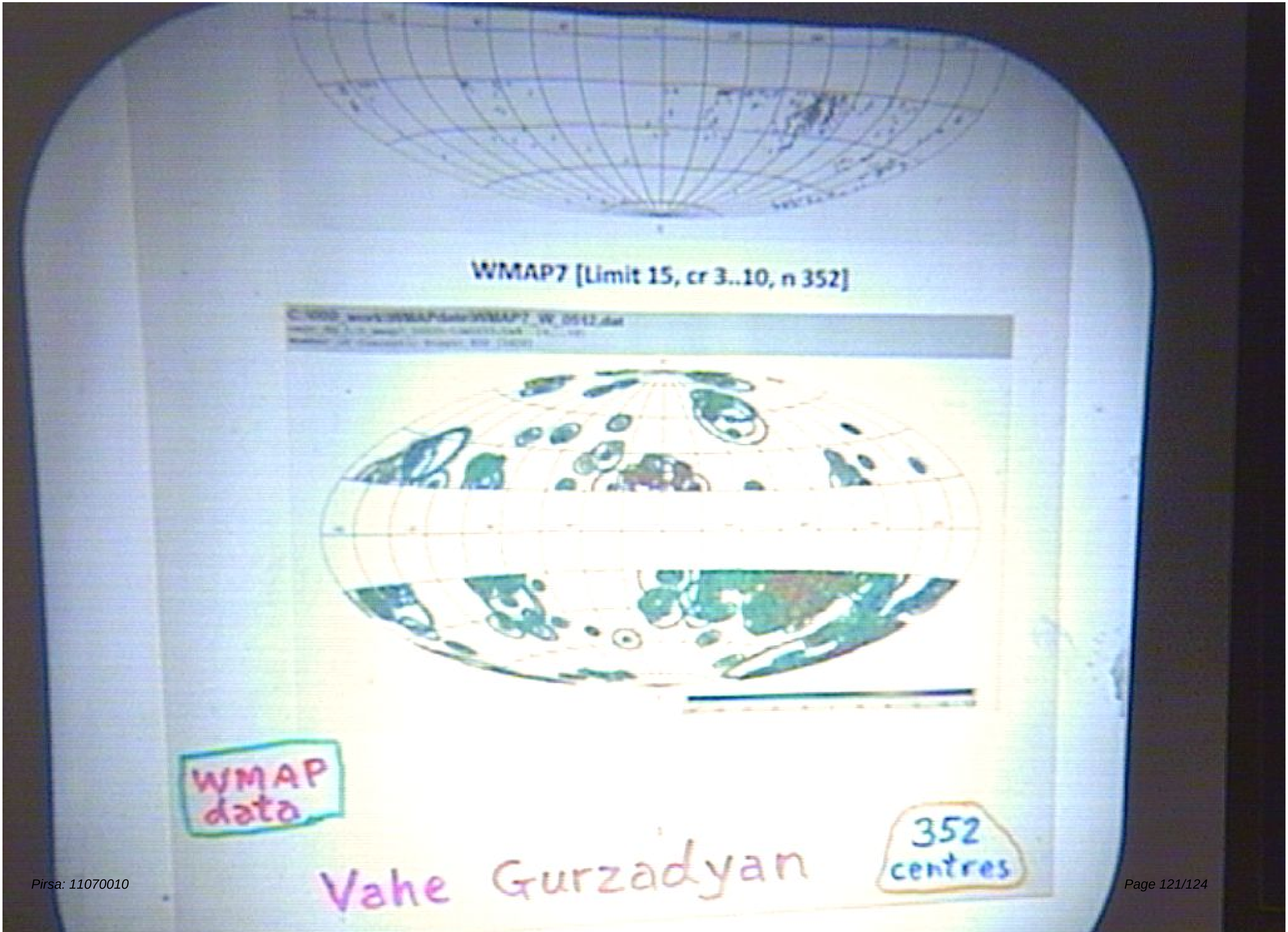

Previous Aeon to Our Own
future infinity
us, now
Big Bang

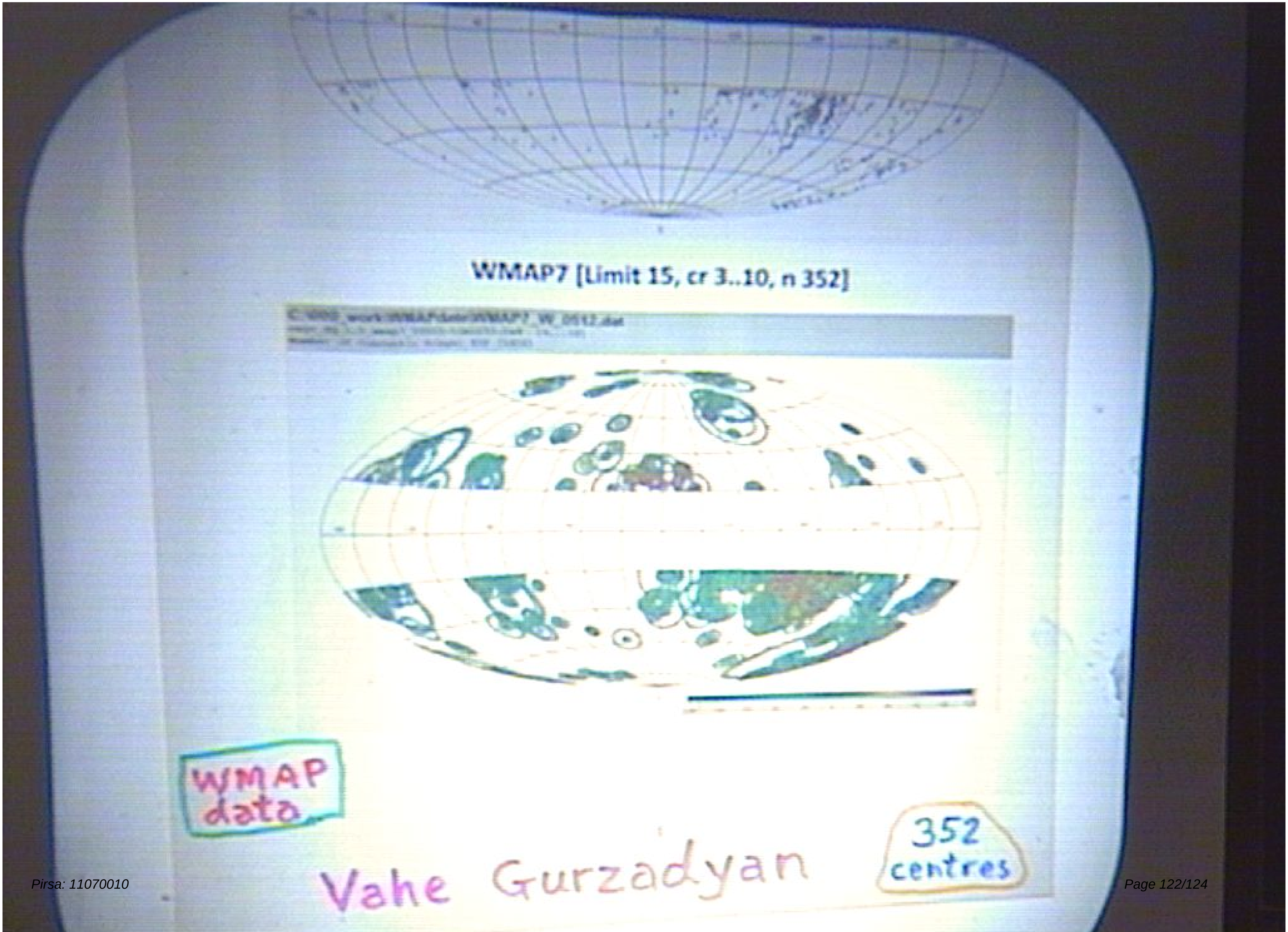
Black-Hole Encounters in the Previous Aeon to Our Own

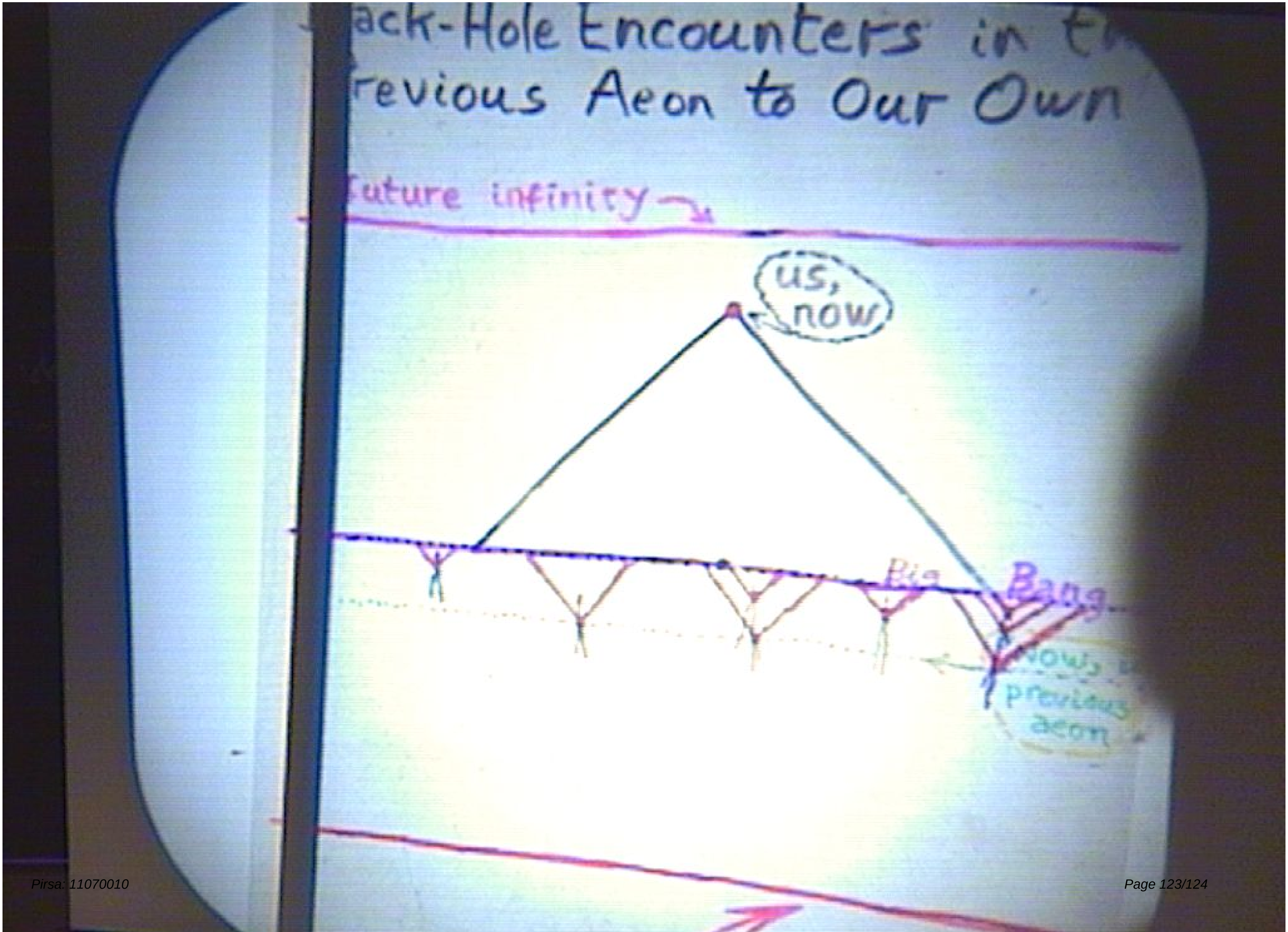


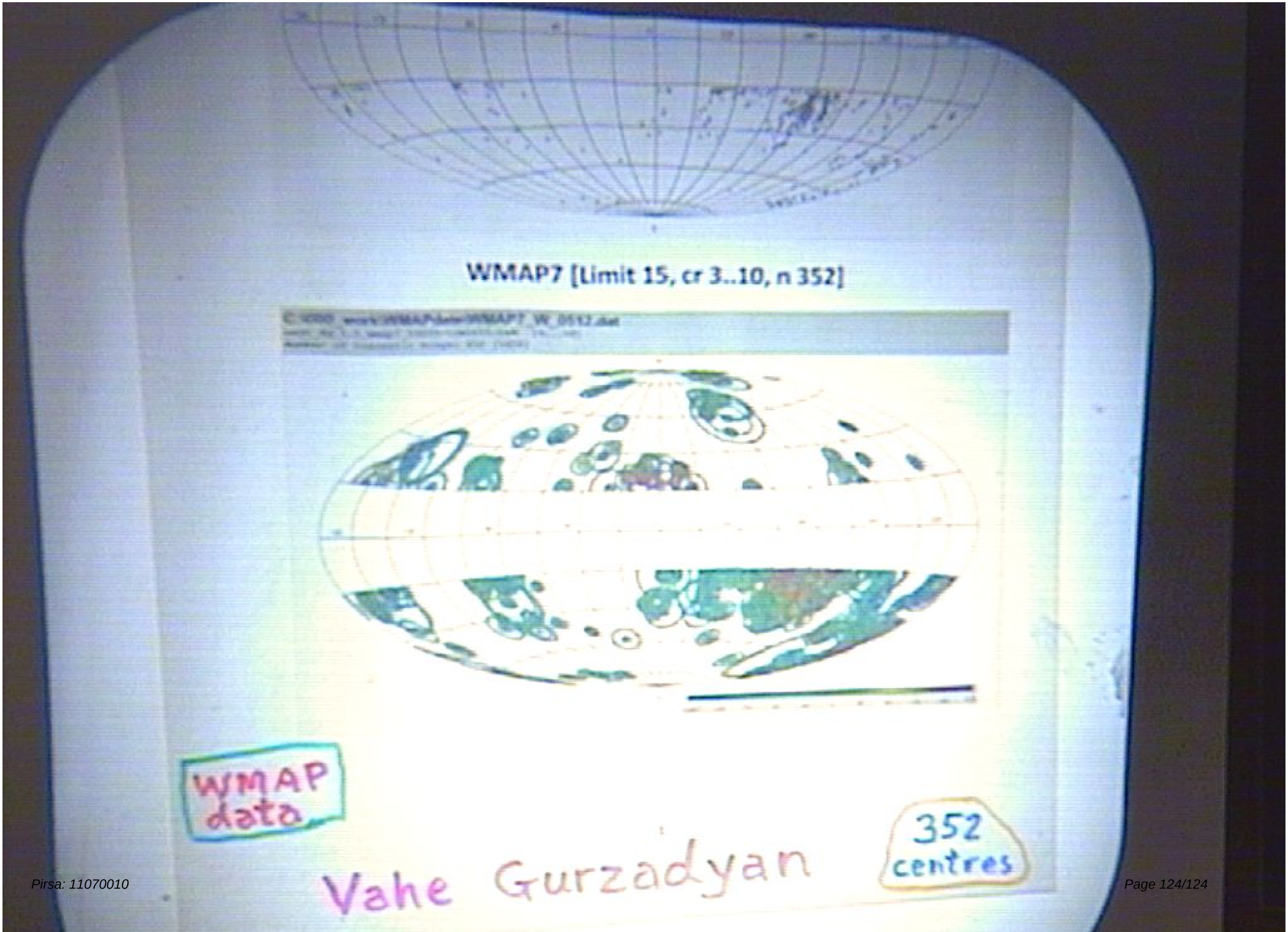


Now, in previous aeon
Maximum ring °radius
~20°
Tod
Nelson & Wilson-Ewing


WMAP7 [Limit 15, cr 3..10, n 352]
WMAP data
352 centres
Vahe Gurzadyan


WMAP7 [Limit 15, cr 3..10, n 352]
WMAP data
Vahe Gurzadyan
352 centres


ack-Hole Encounters in th
revious Aeon to Our Own
uture infinity
us,
now
Big
Bang
ow,
previous
aeon


WMAP7 [Limit 15, cr 3..10, n 352]
WMAP data
352 centres
Vahe Gurzadyan