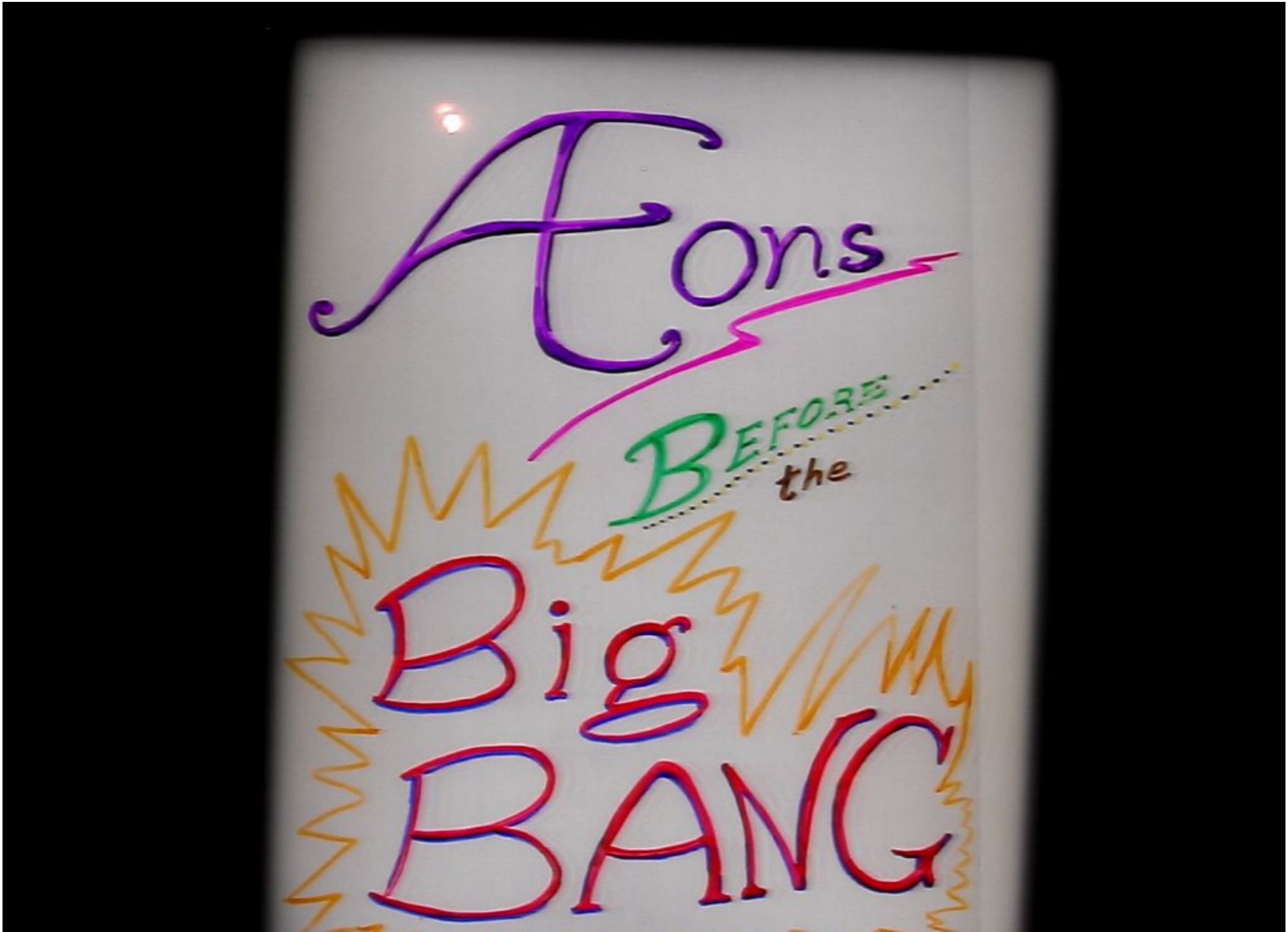
Title: Conformal Cyclic Cosmology: Equations of Evolution, Observational Consequences

Date: Apr 06, 2011 02:00 PM

URL: http://pirsa.org/11040063

Abstract: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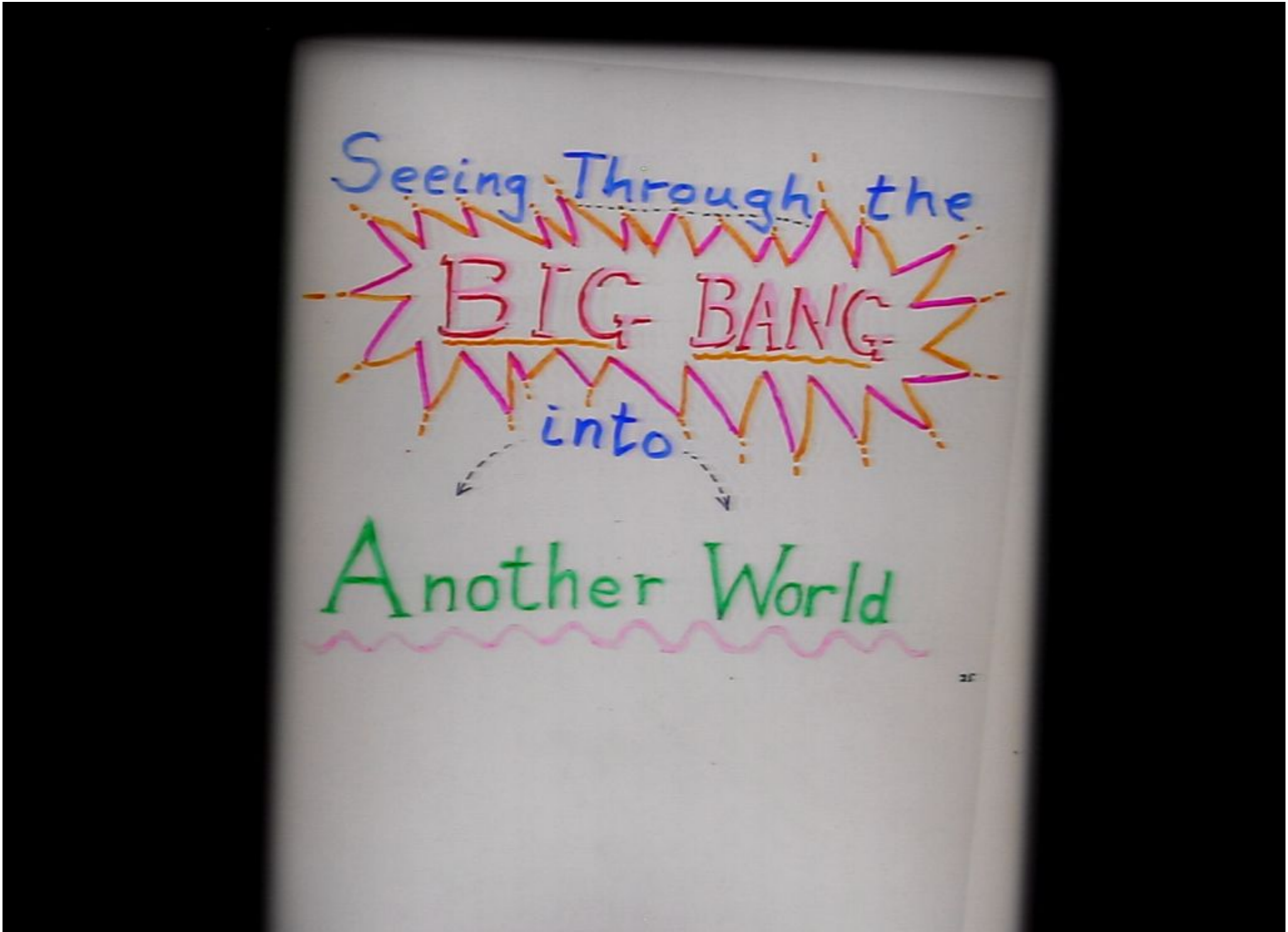
Seeing Through the
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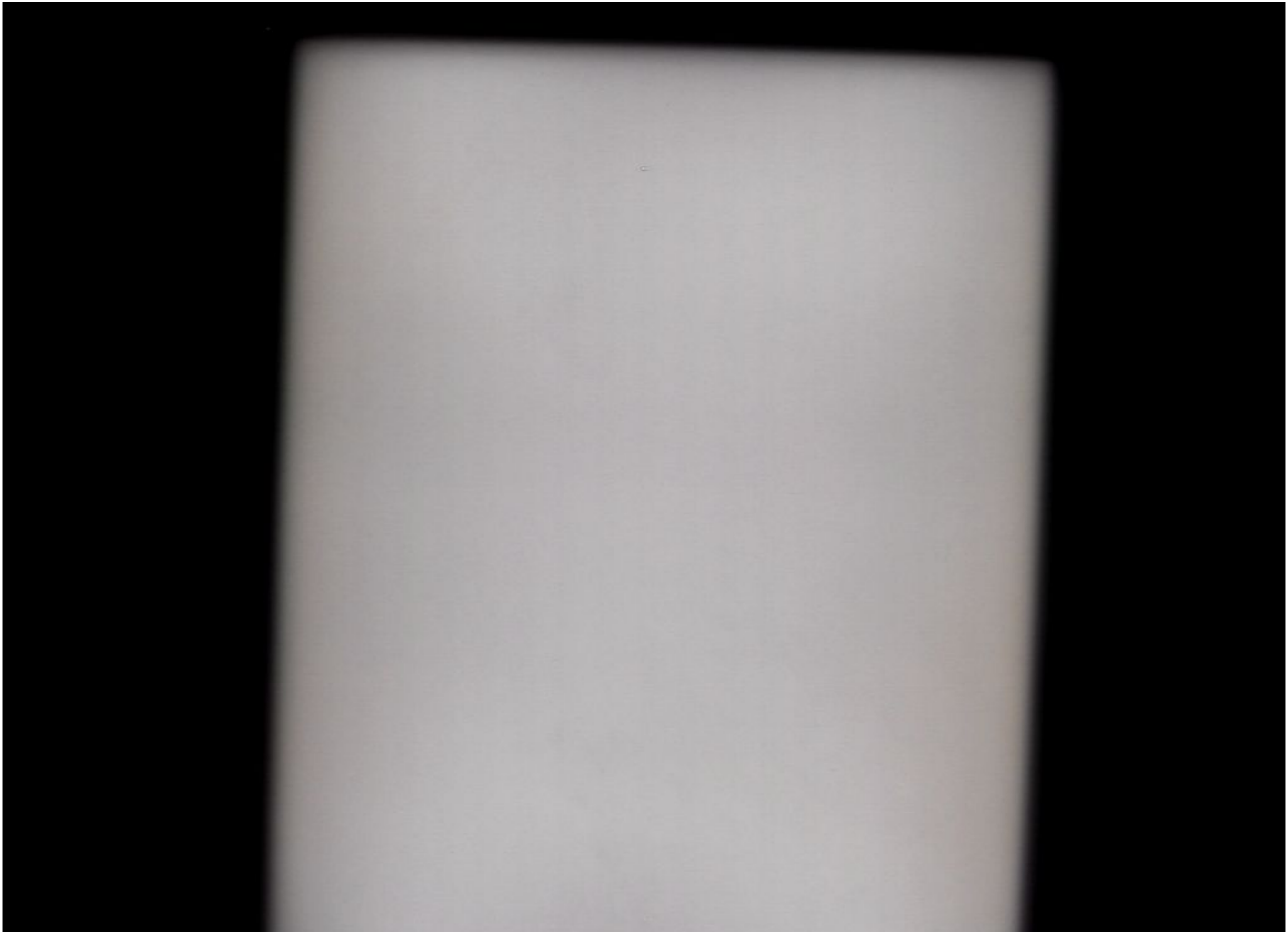
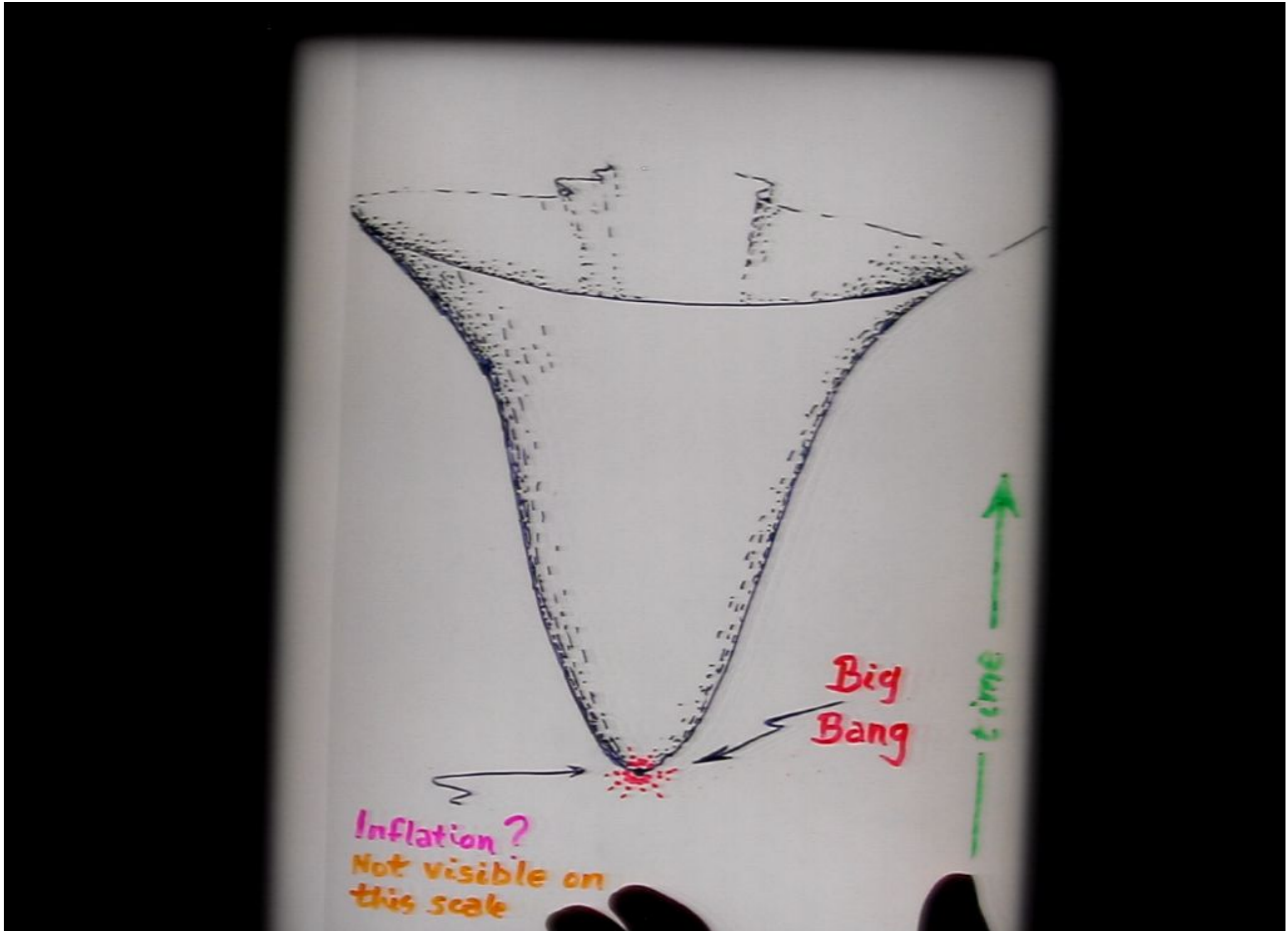
into
Another World

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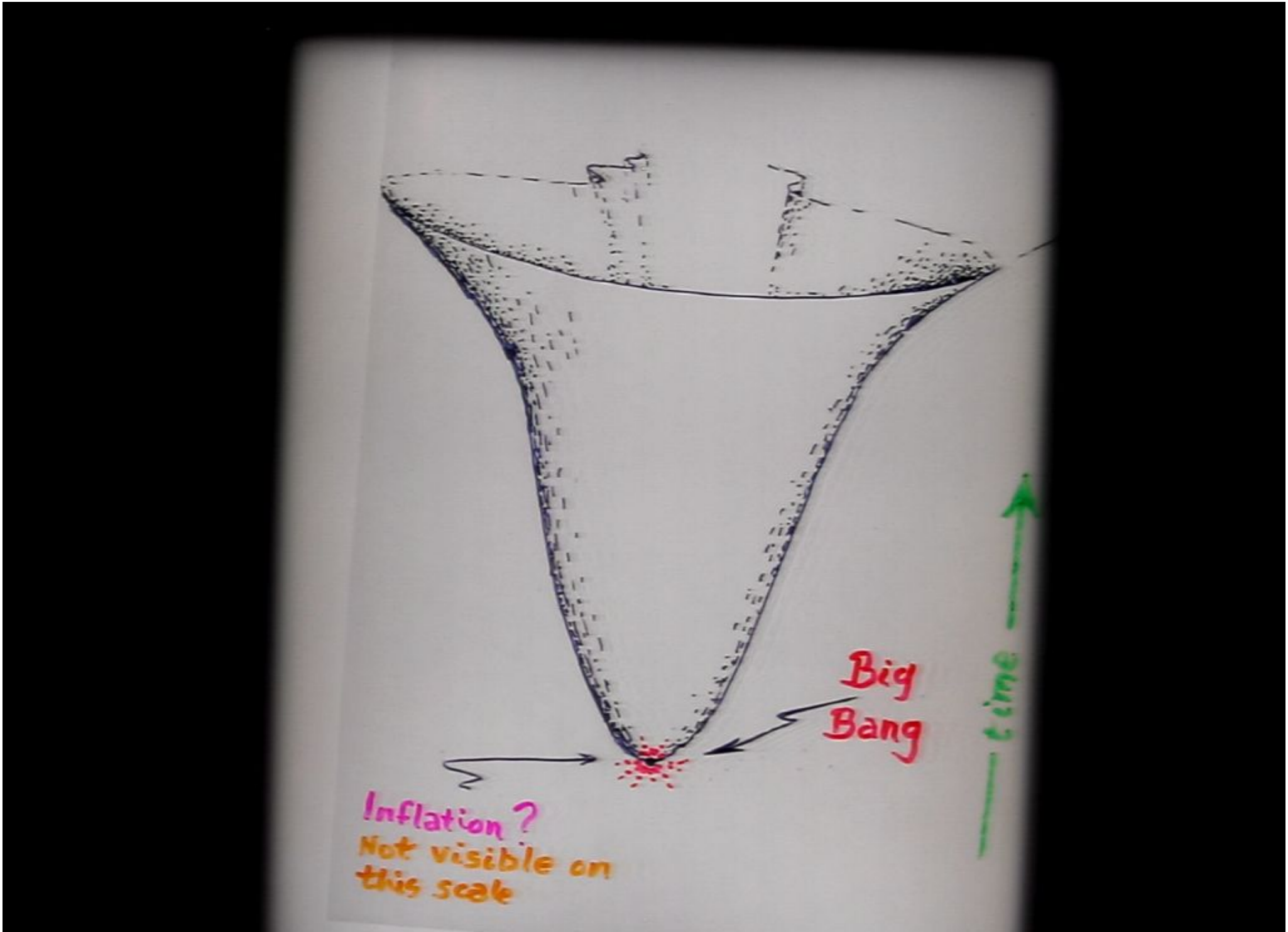
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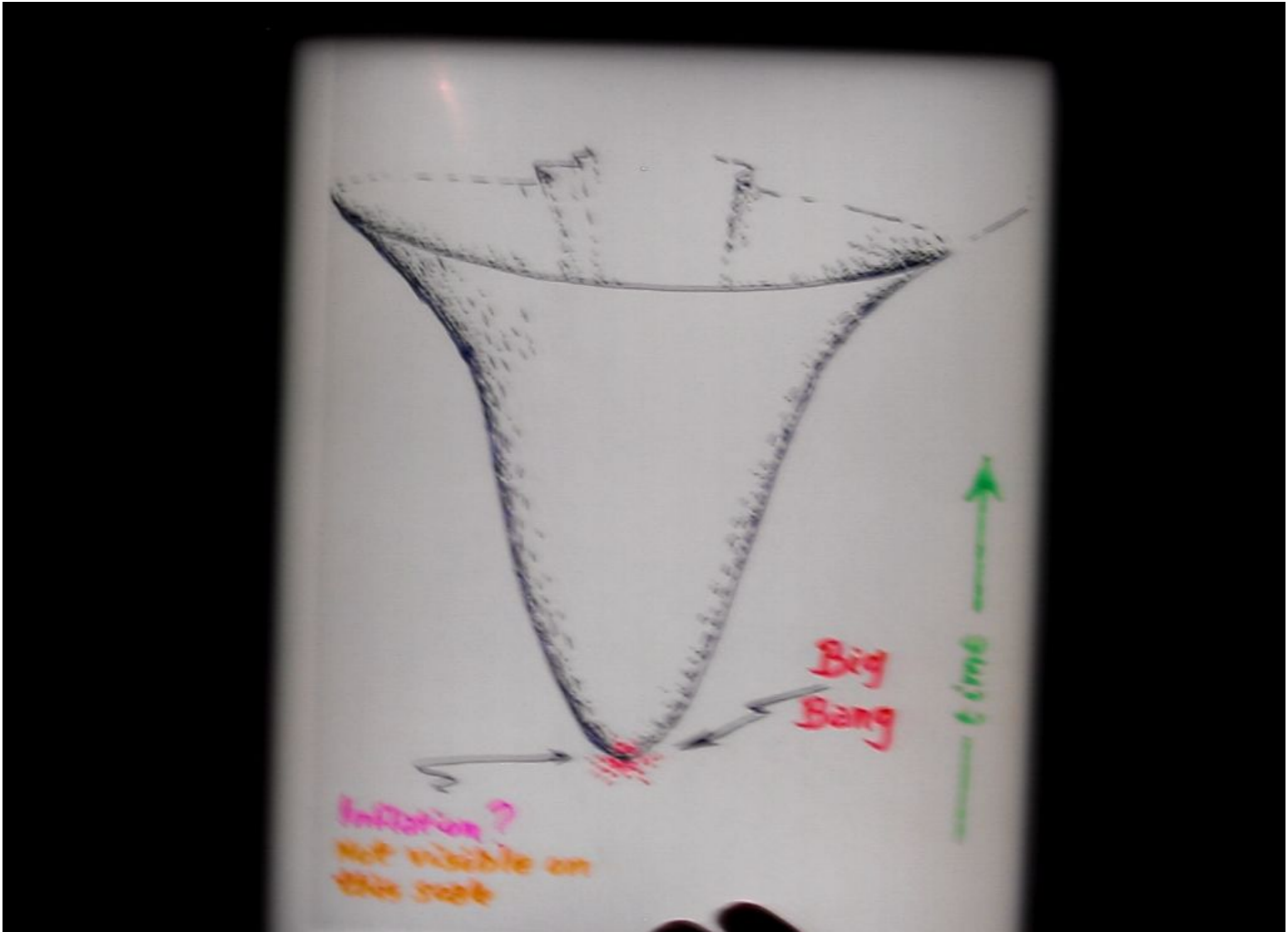
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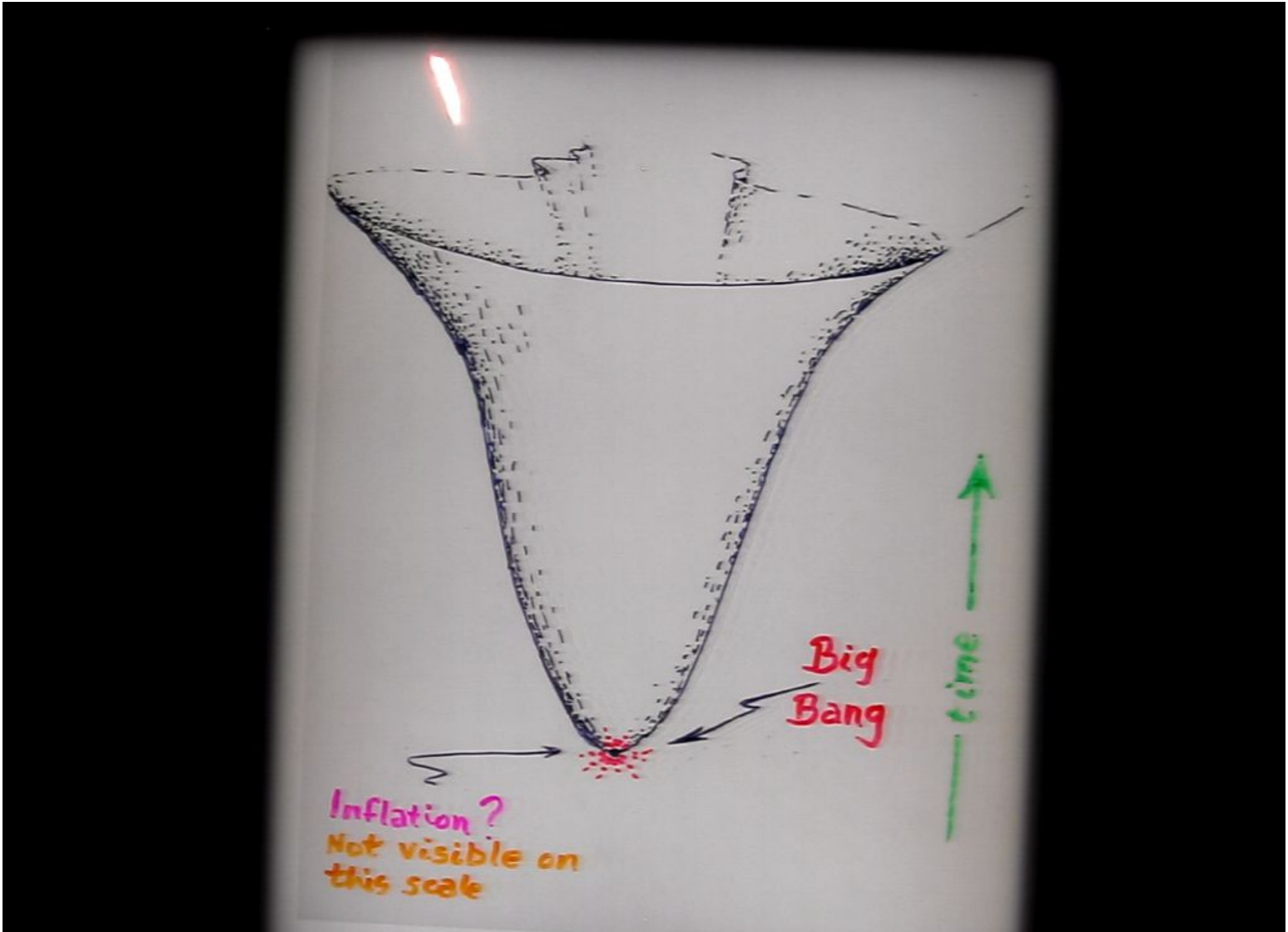
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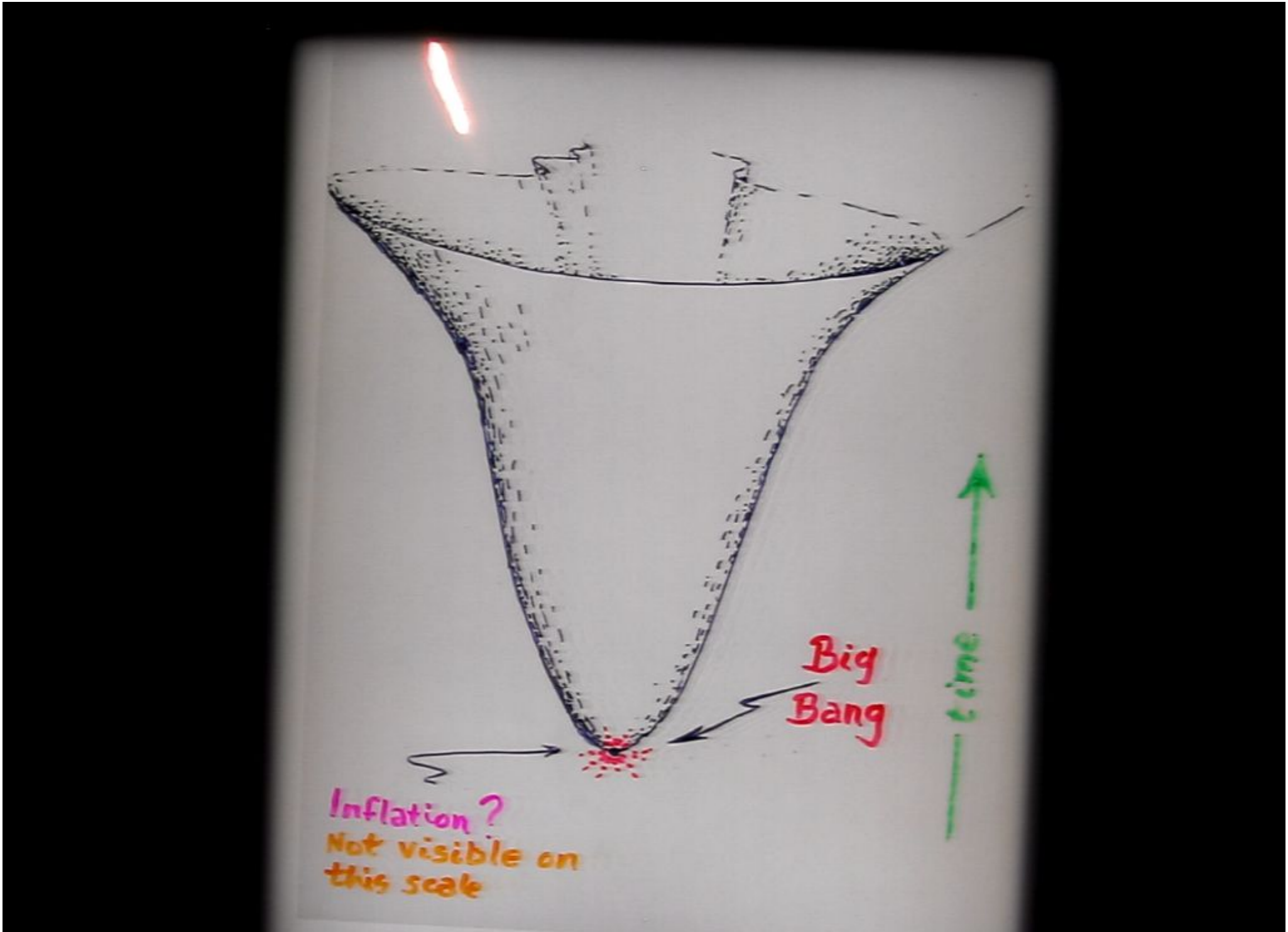
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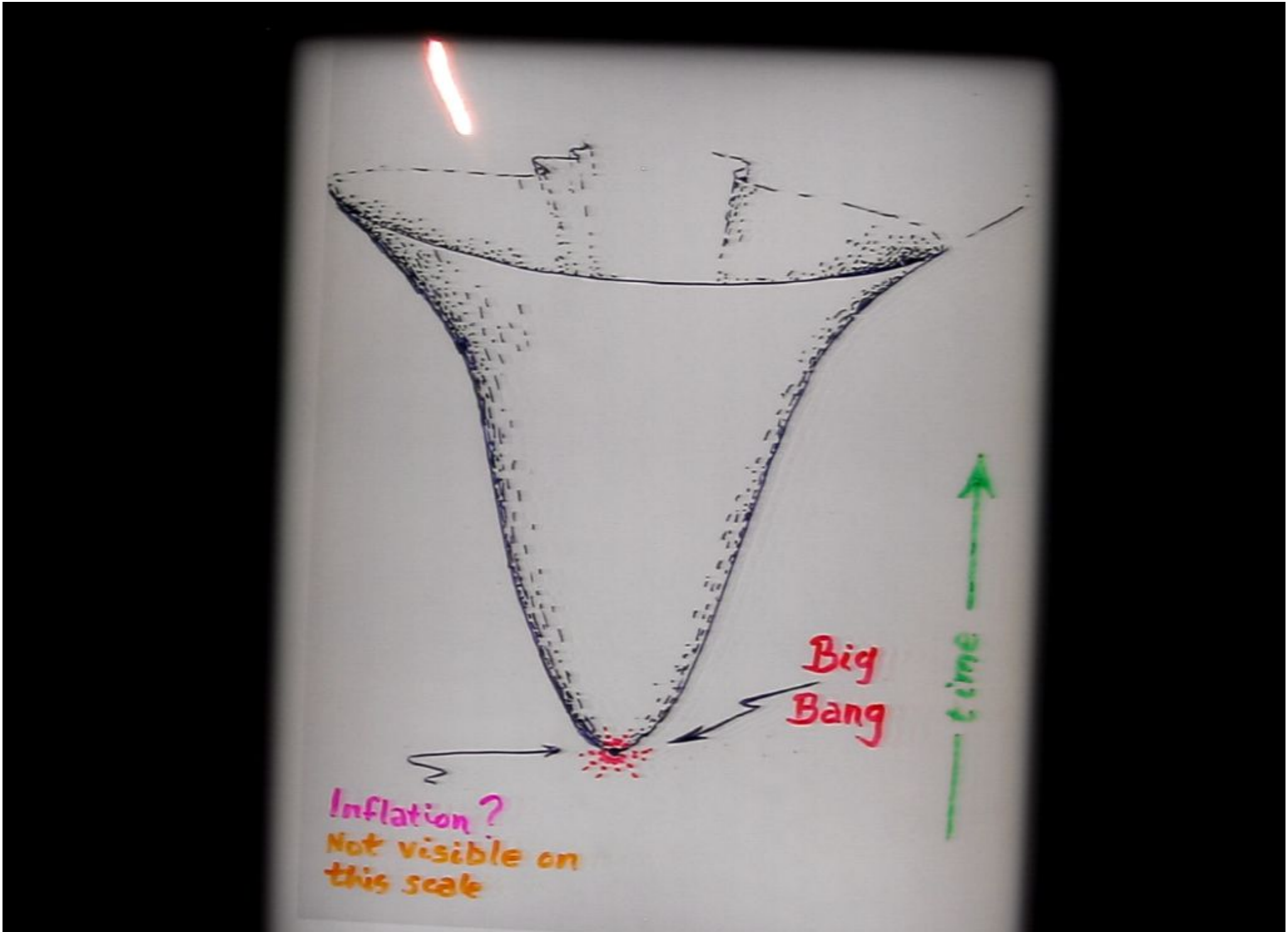
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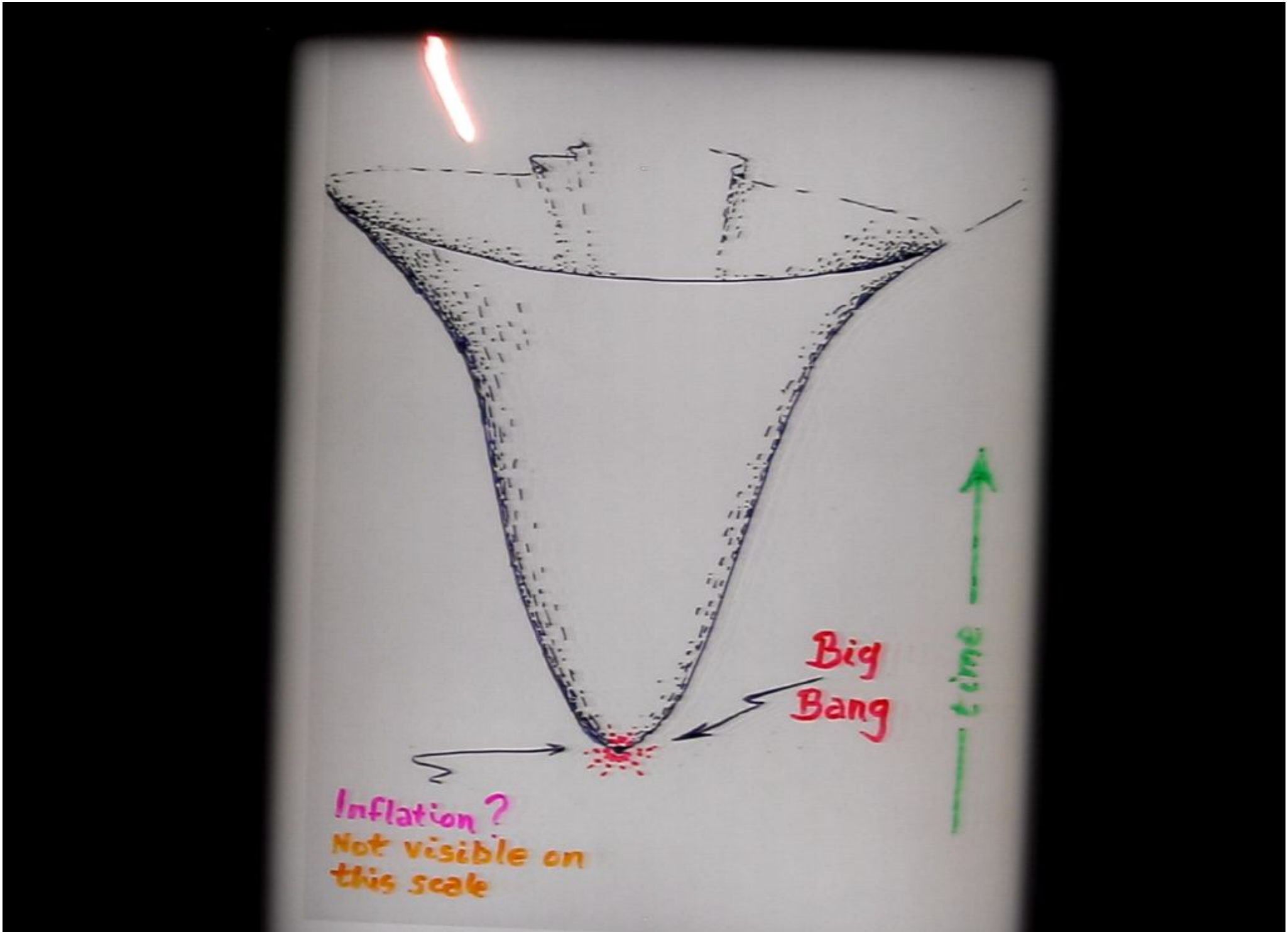
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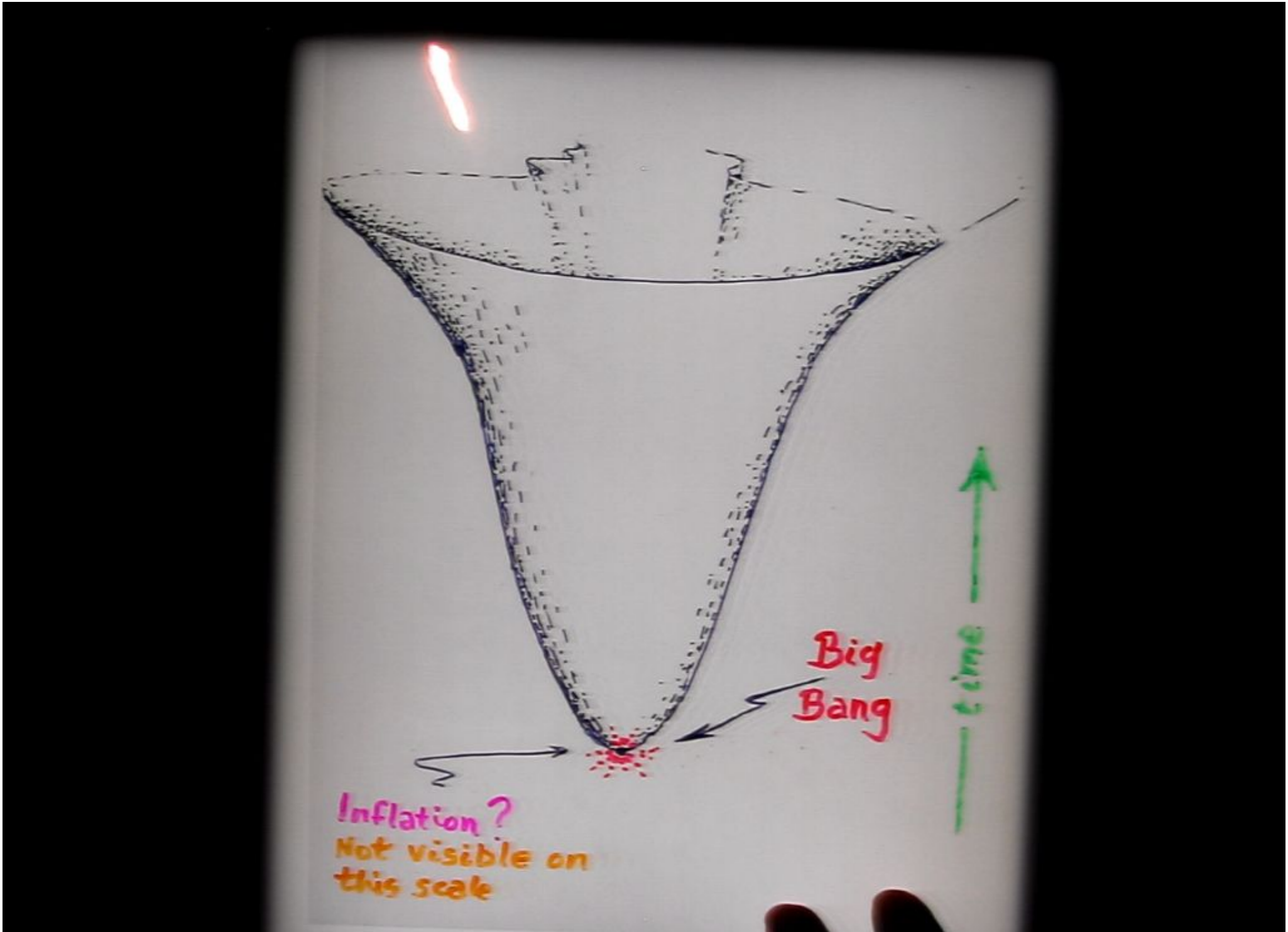
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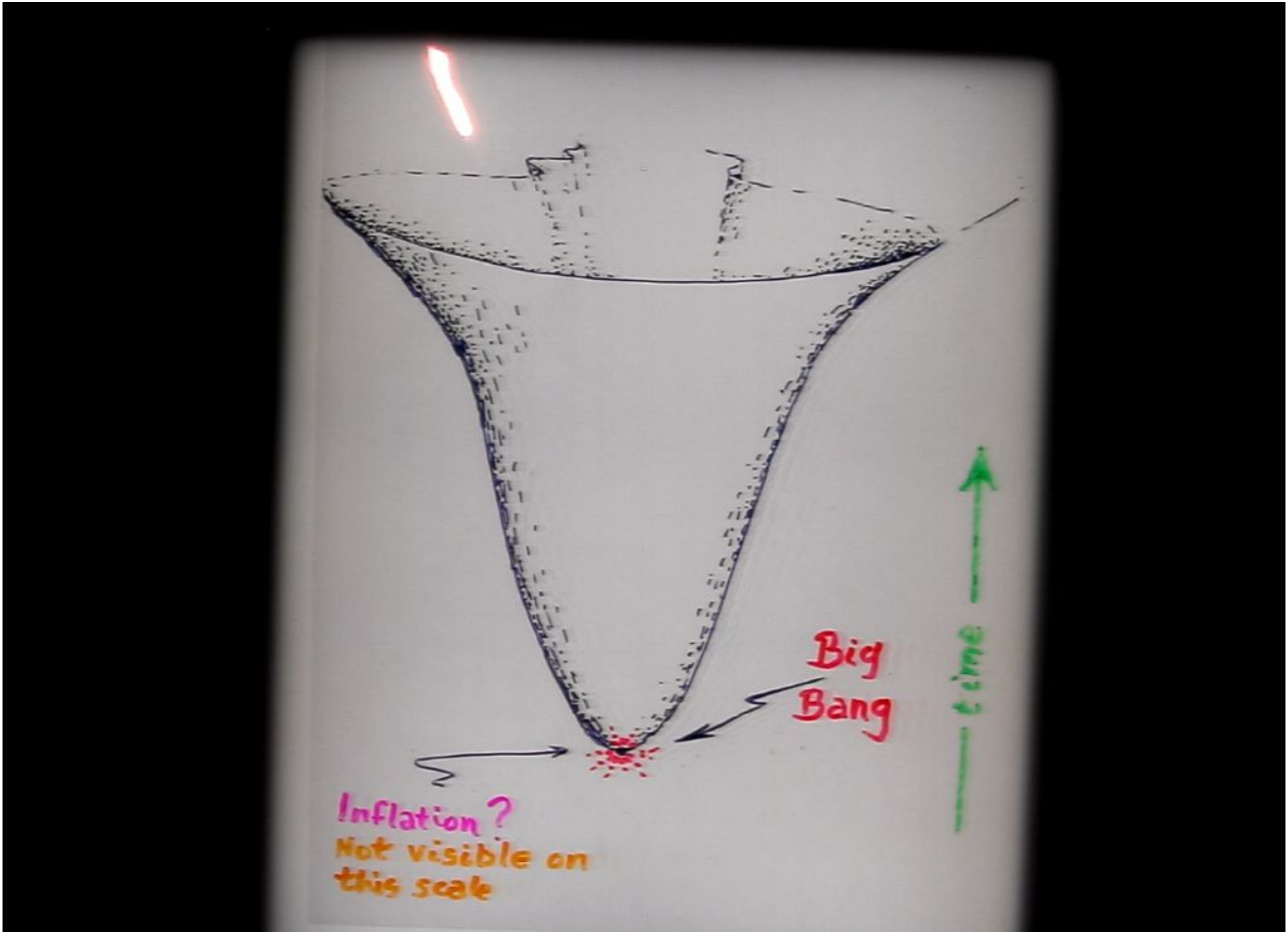
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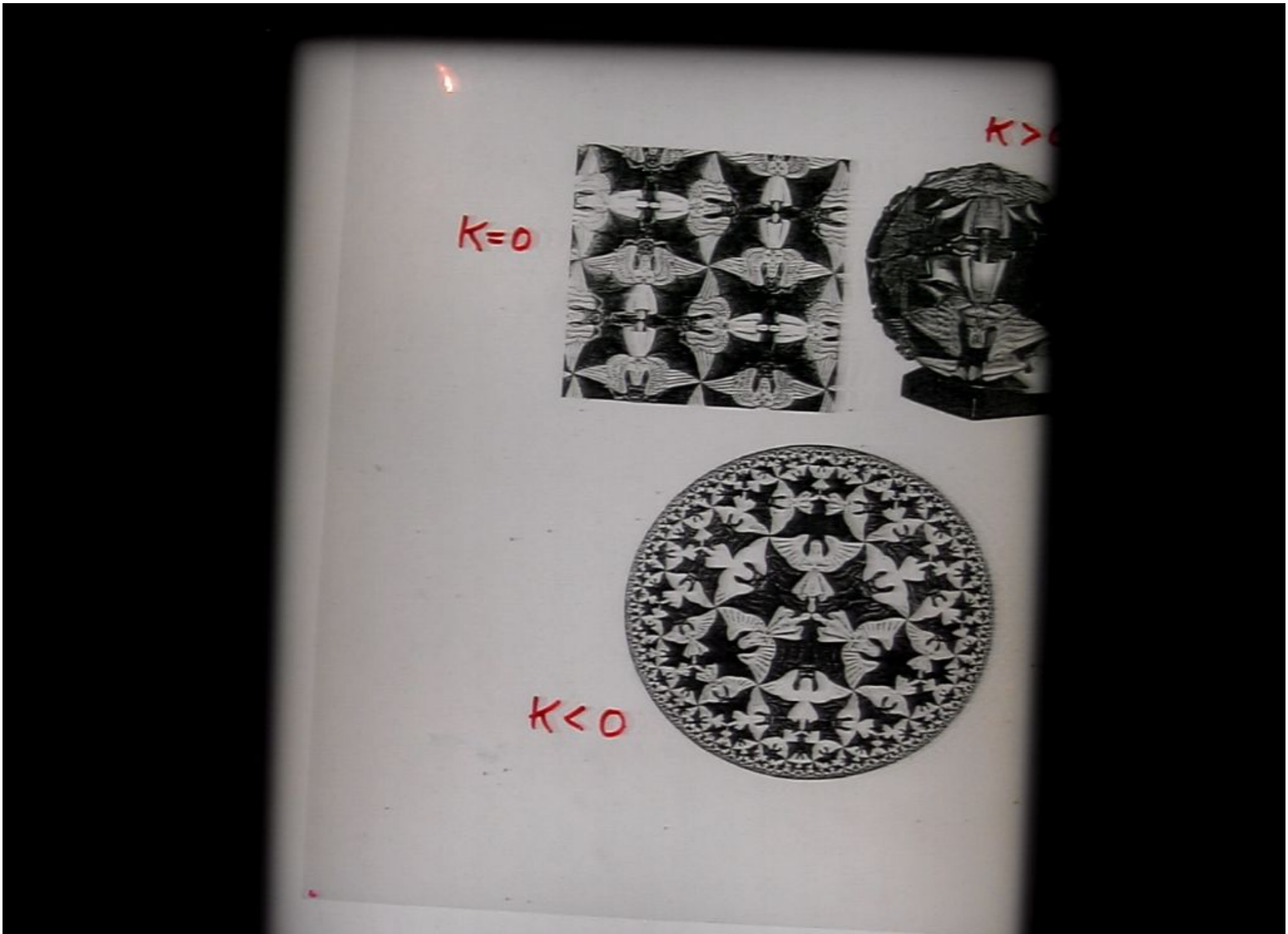
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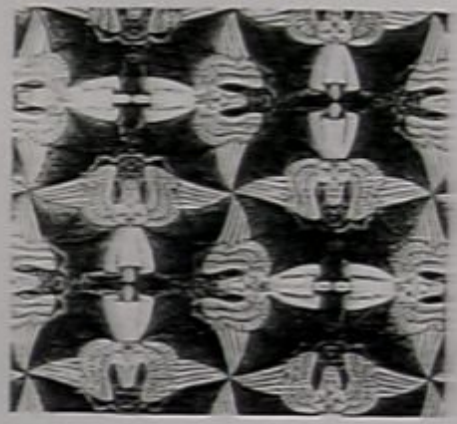



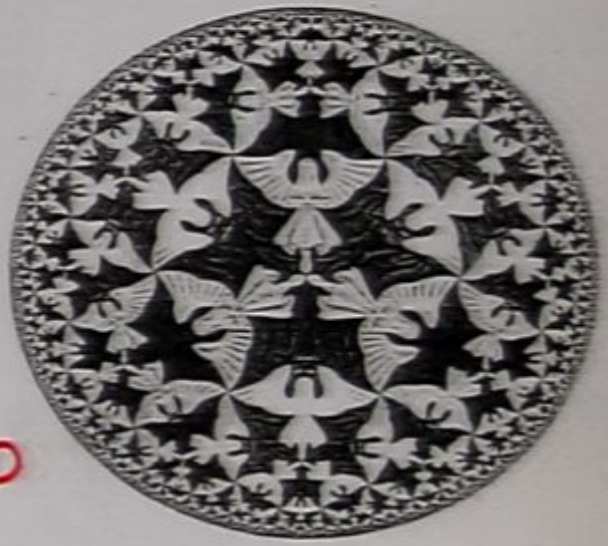

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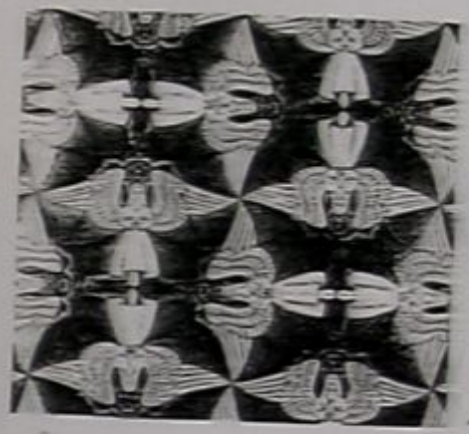



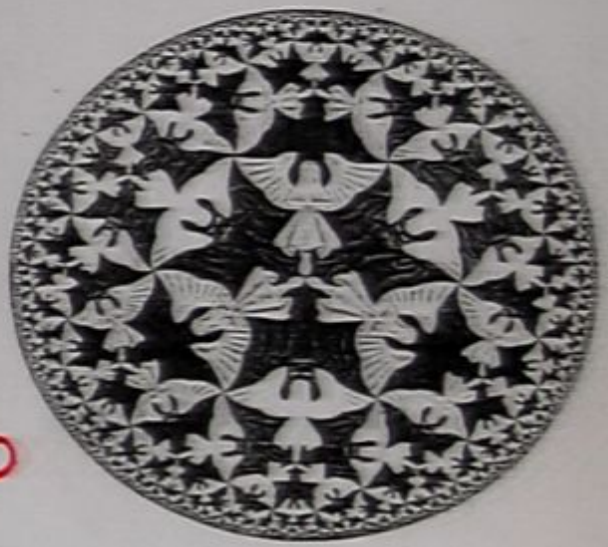

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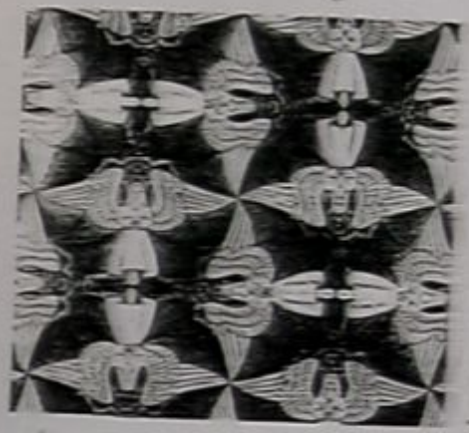



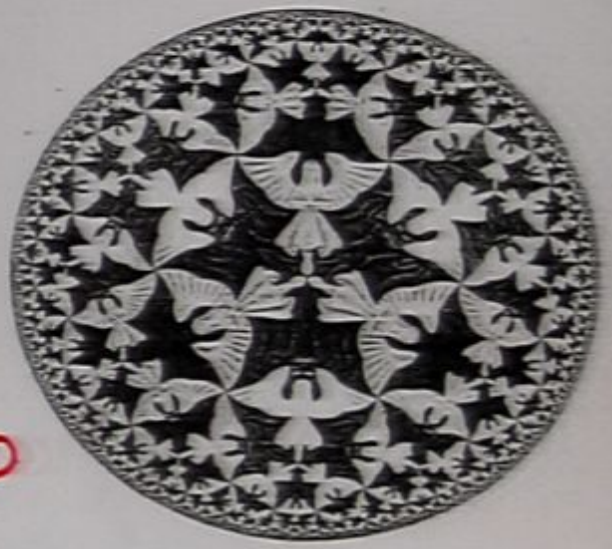

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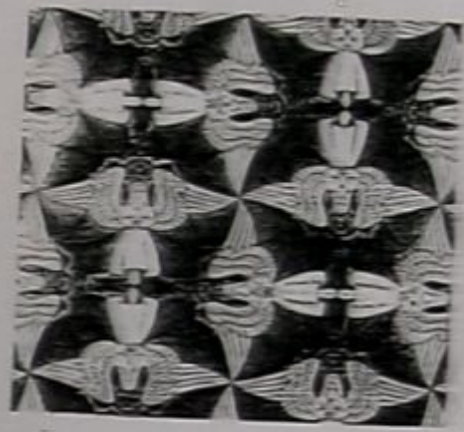



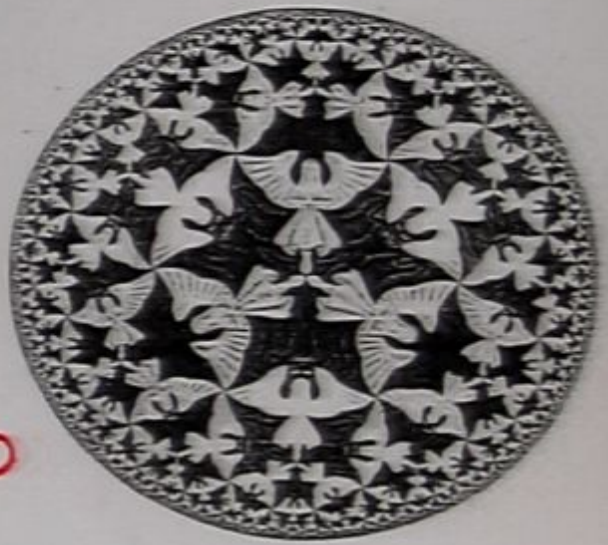

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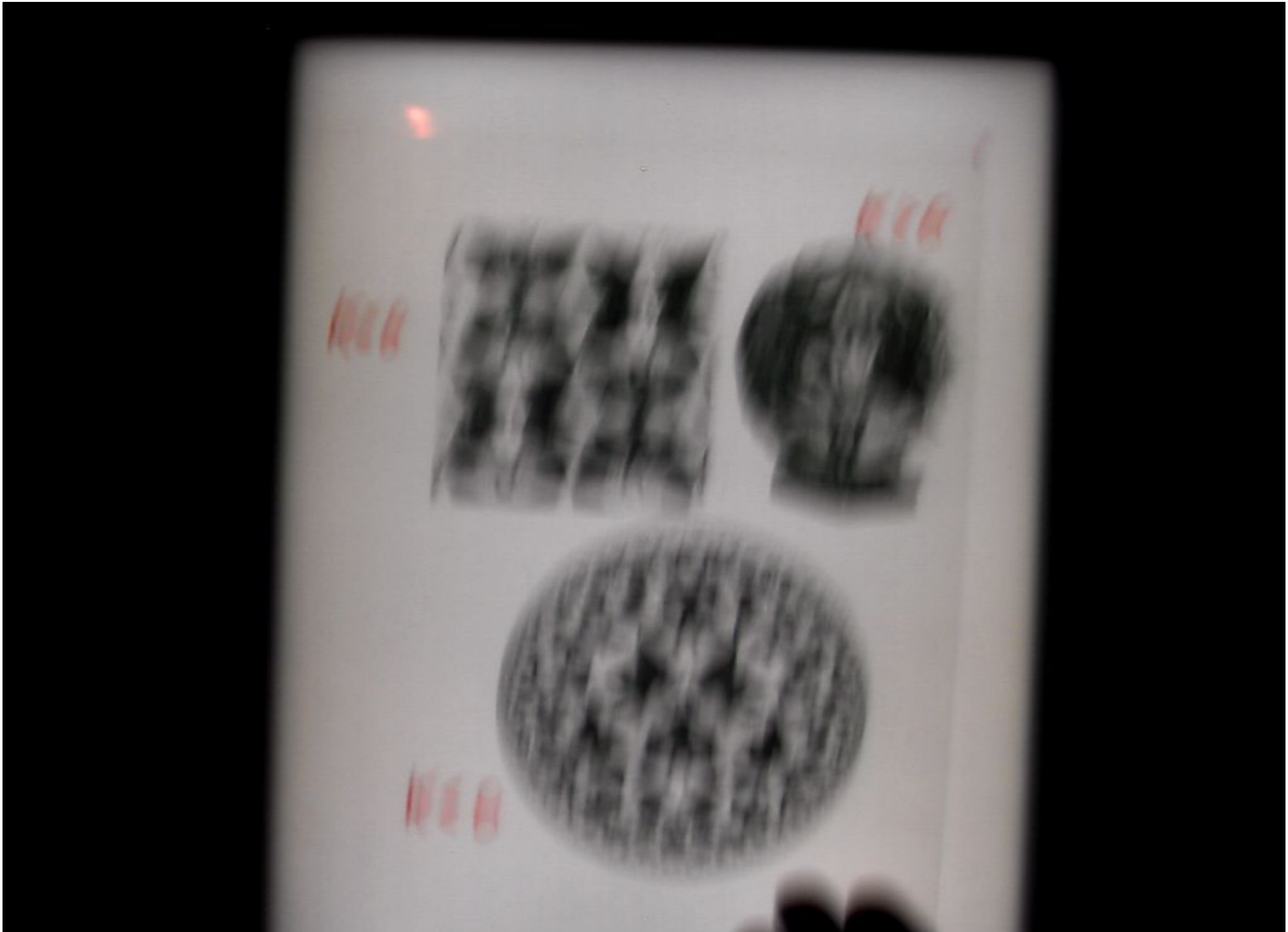

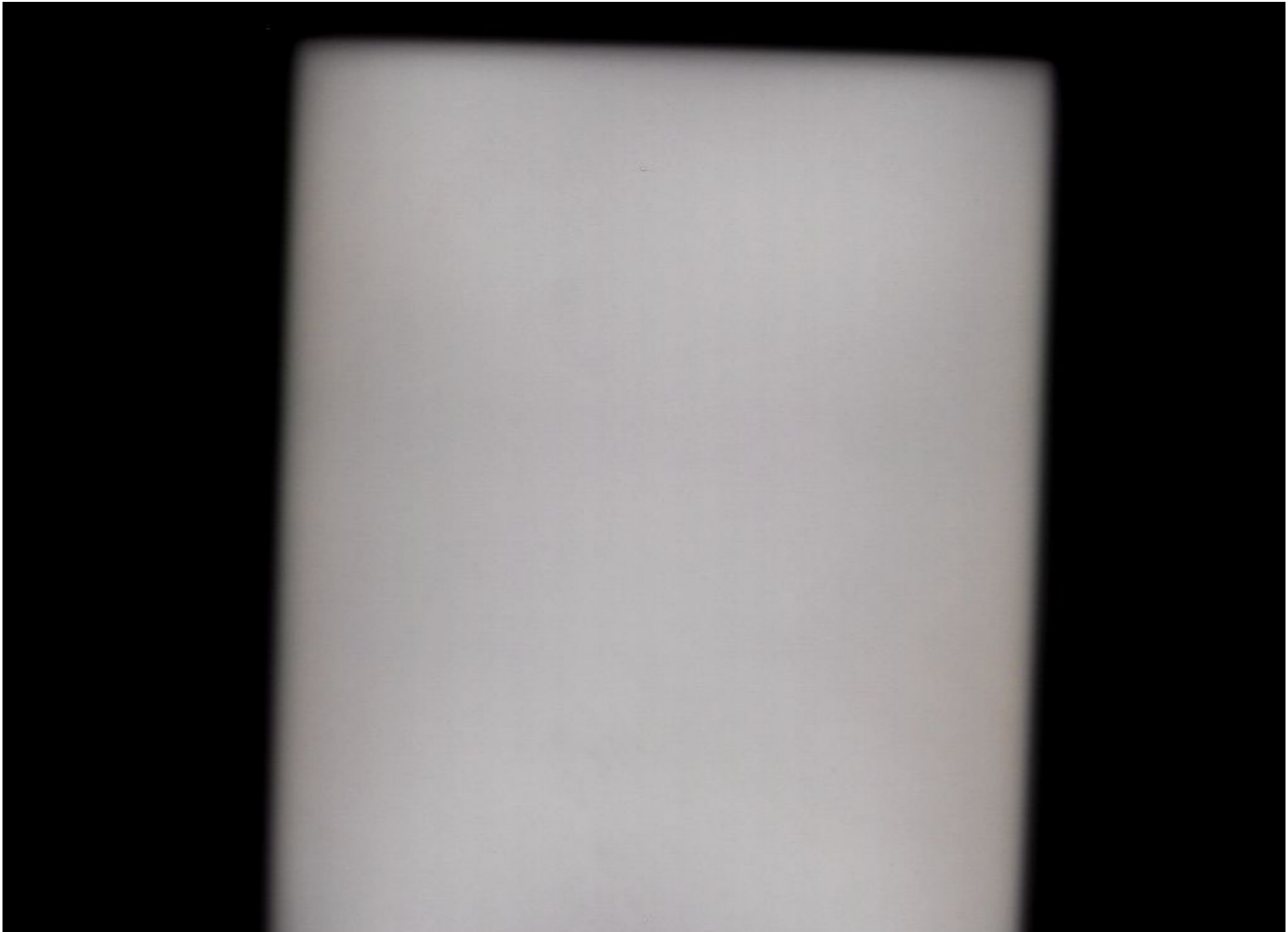

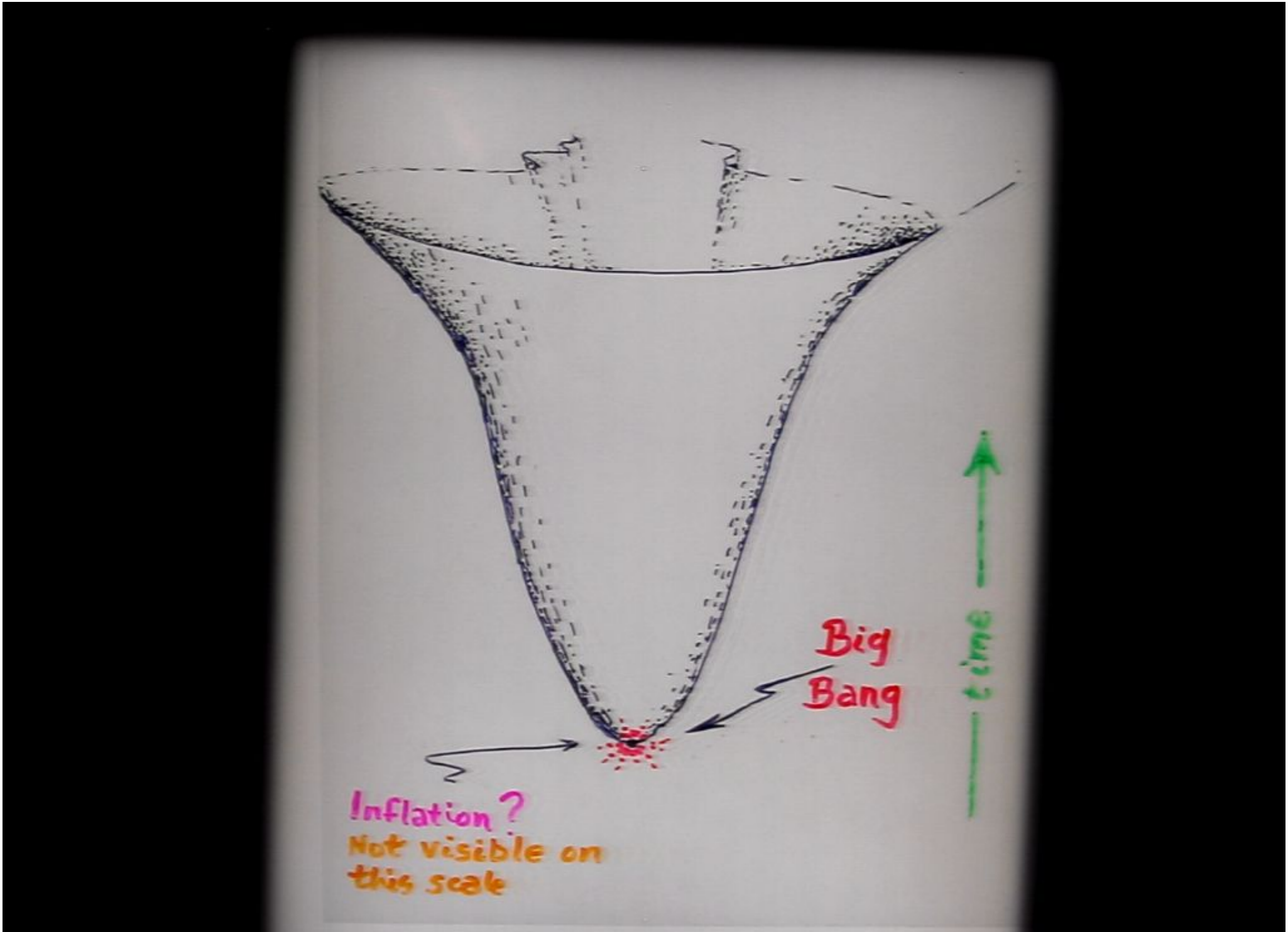
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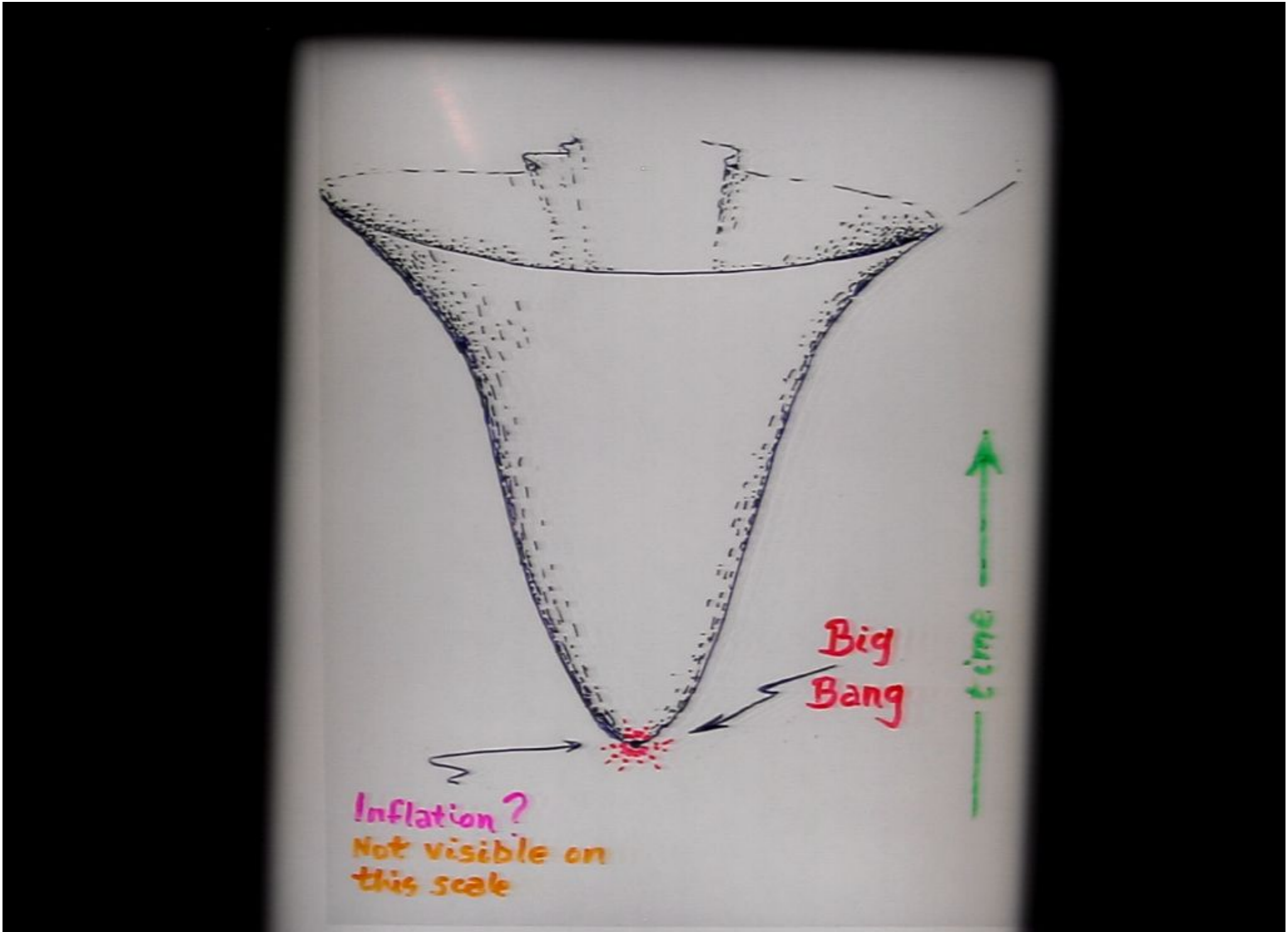
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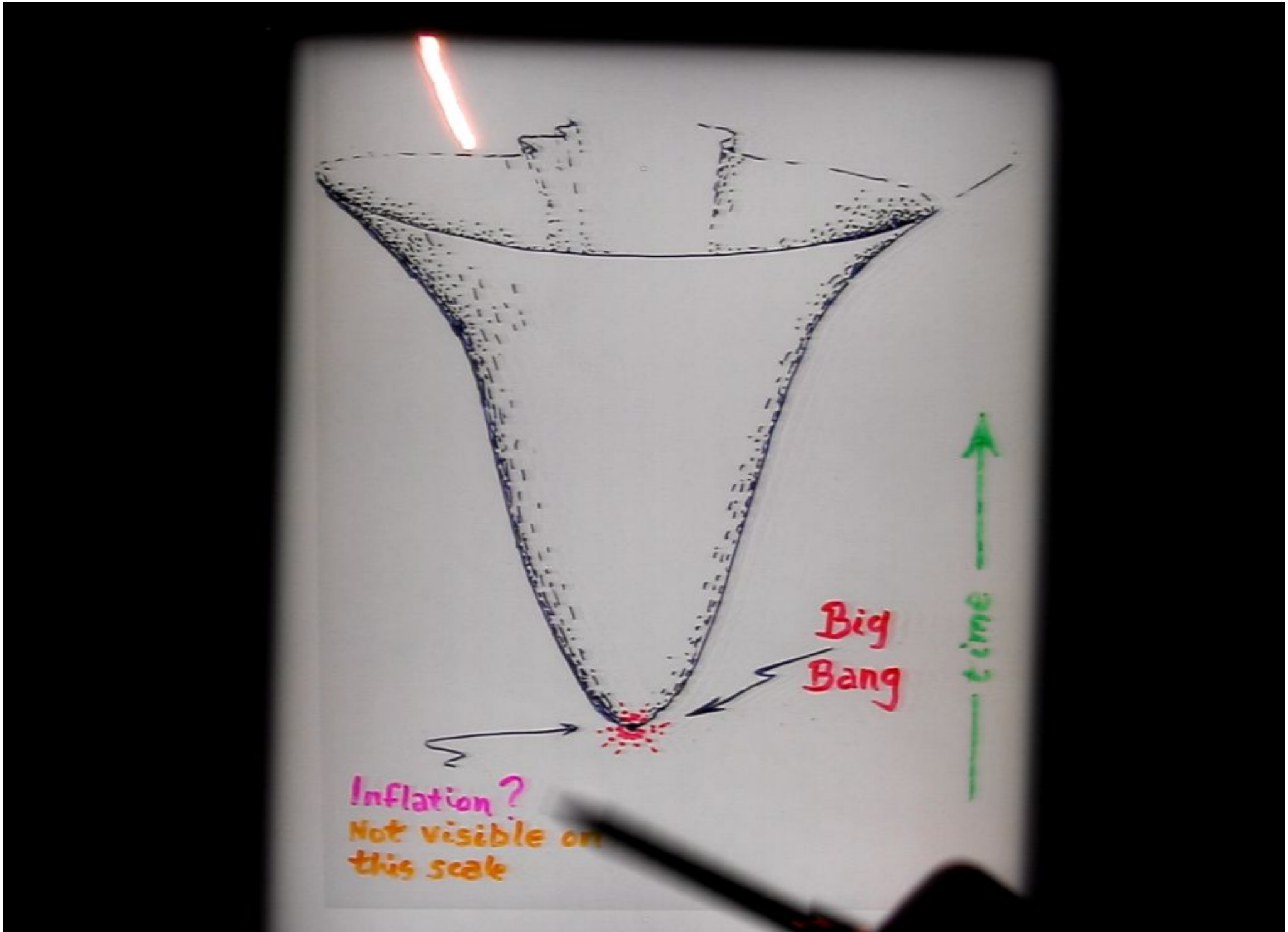
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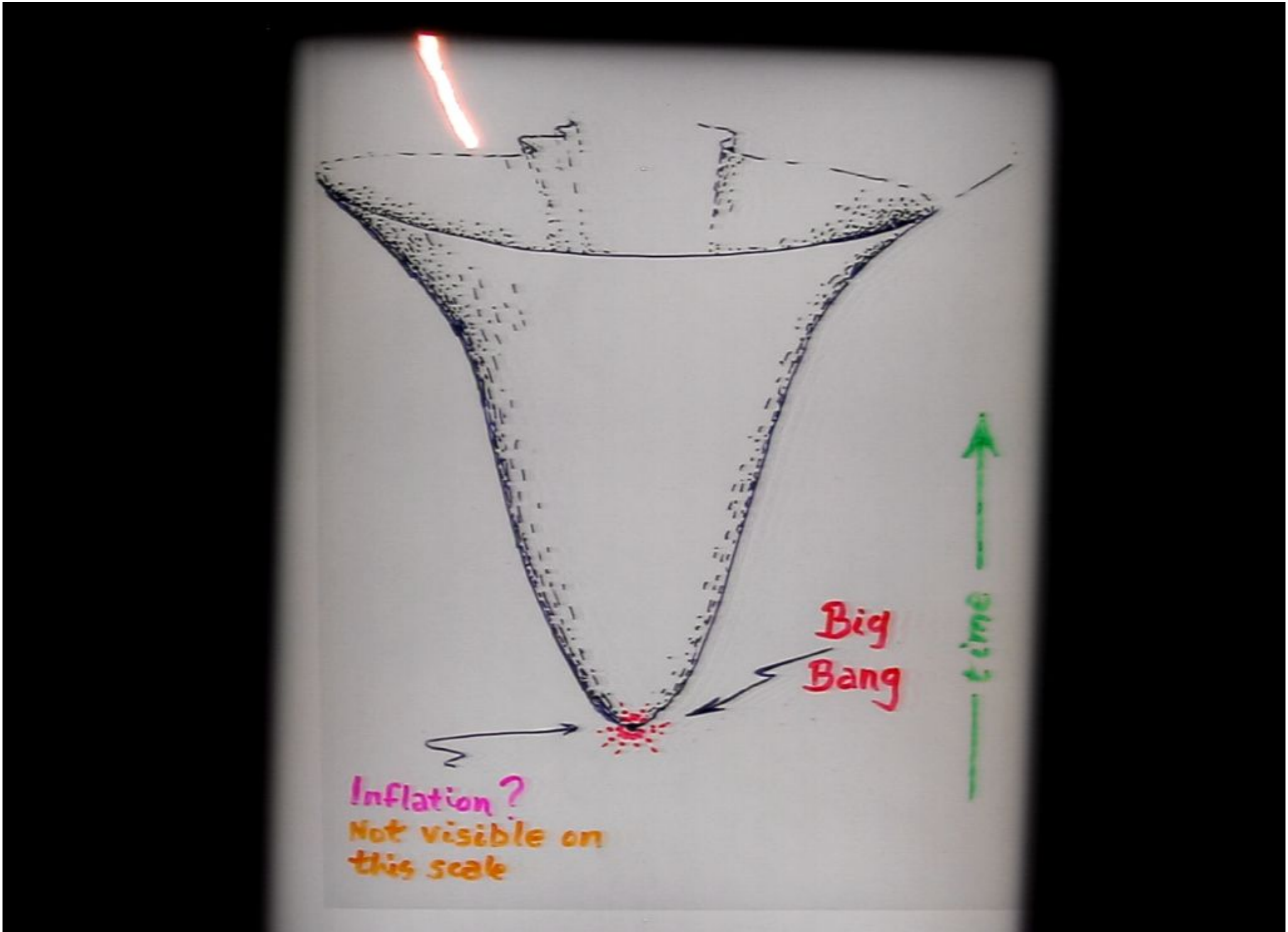
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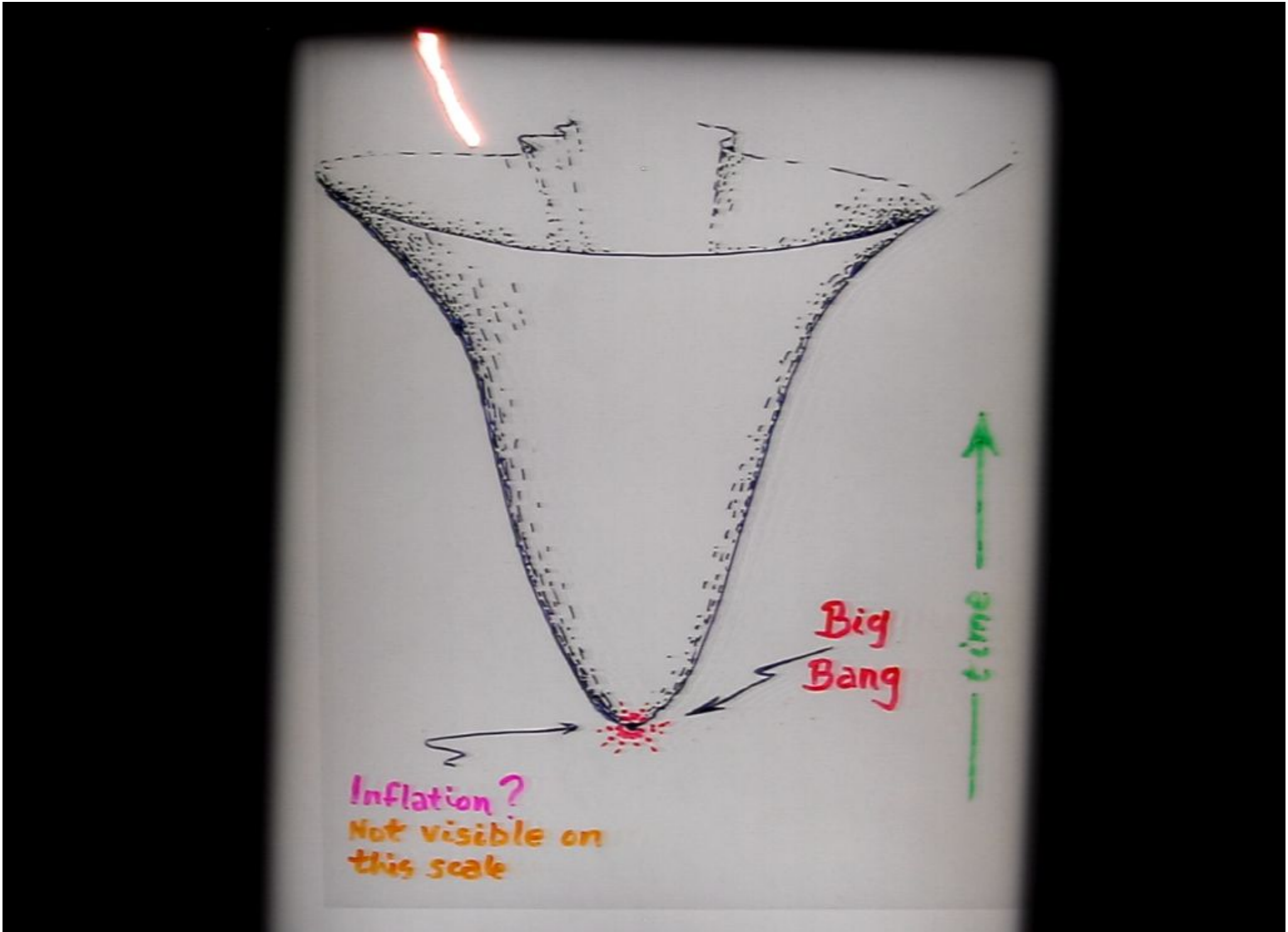
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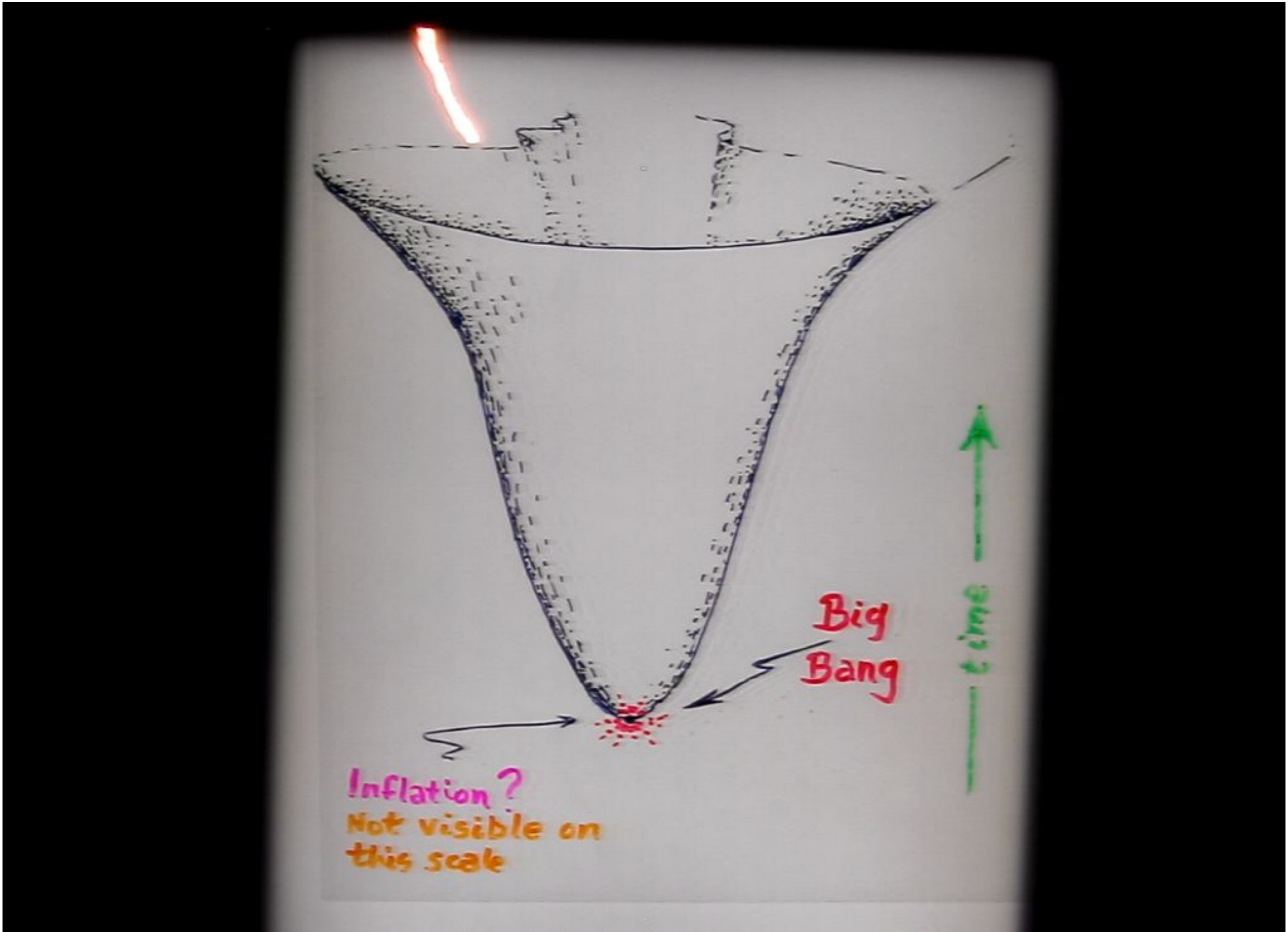
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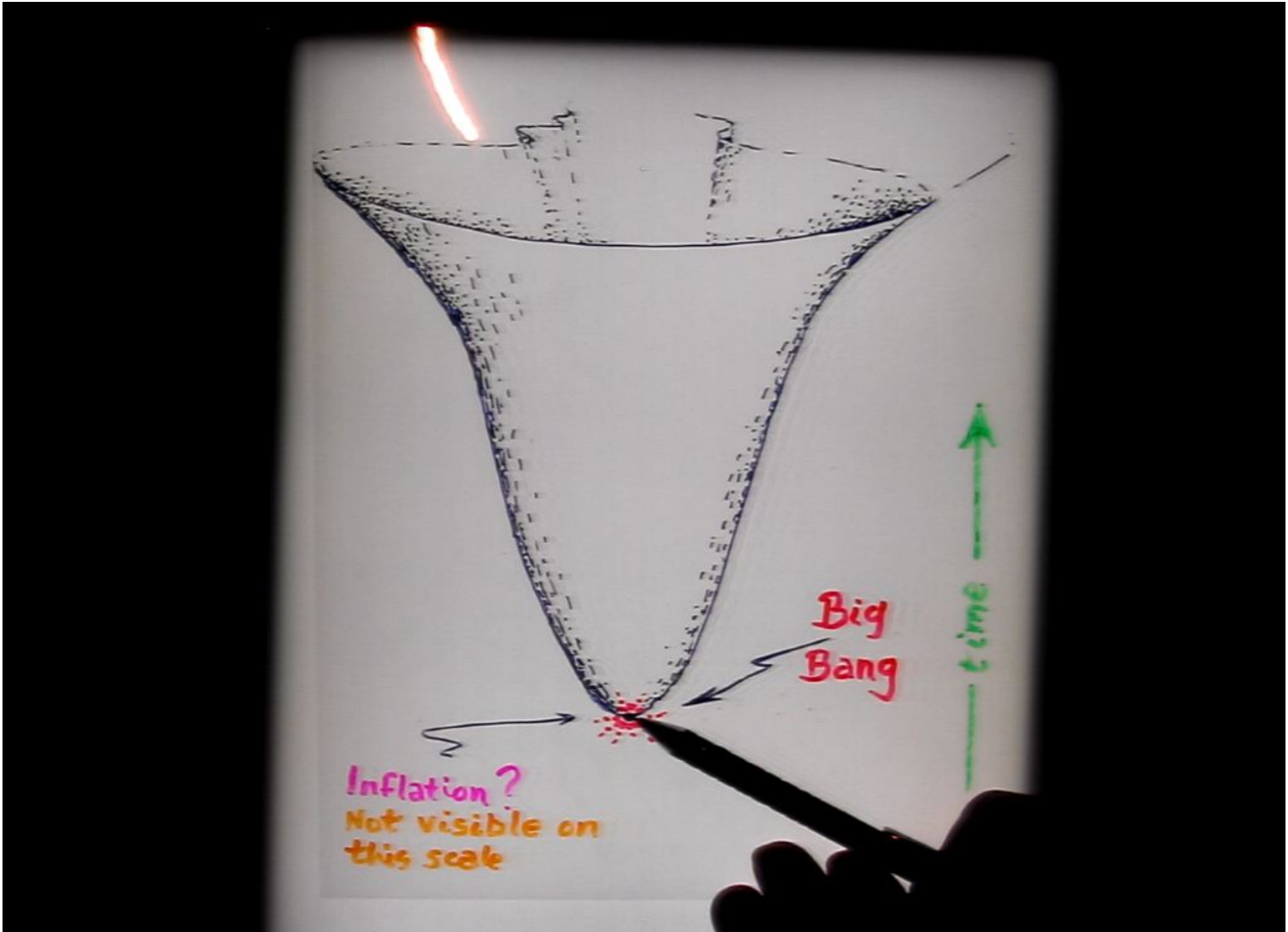
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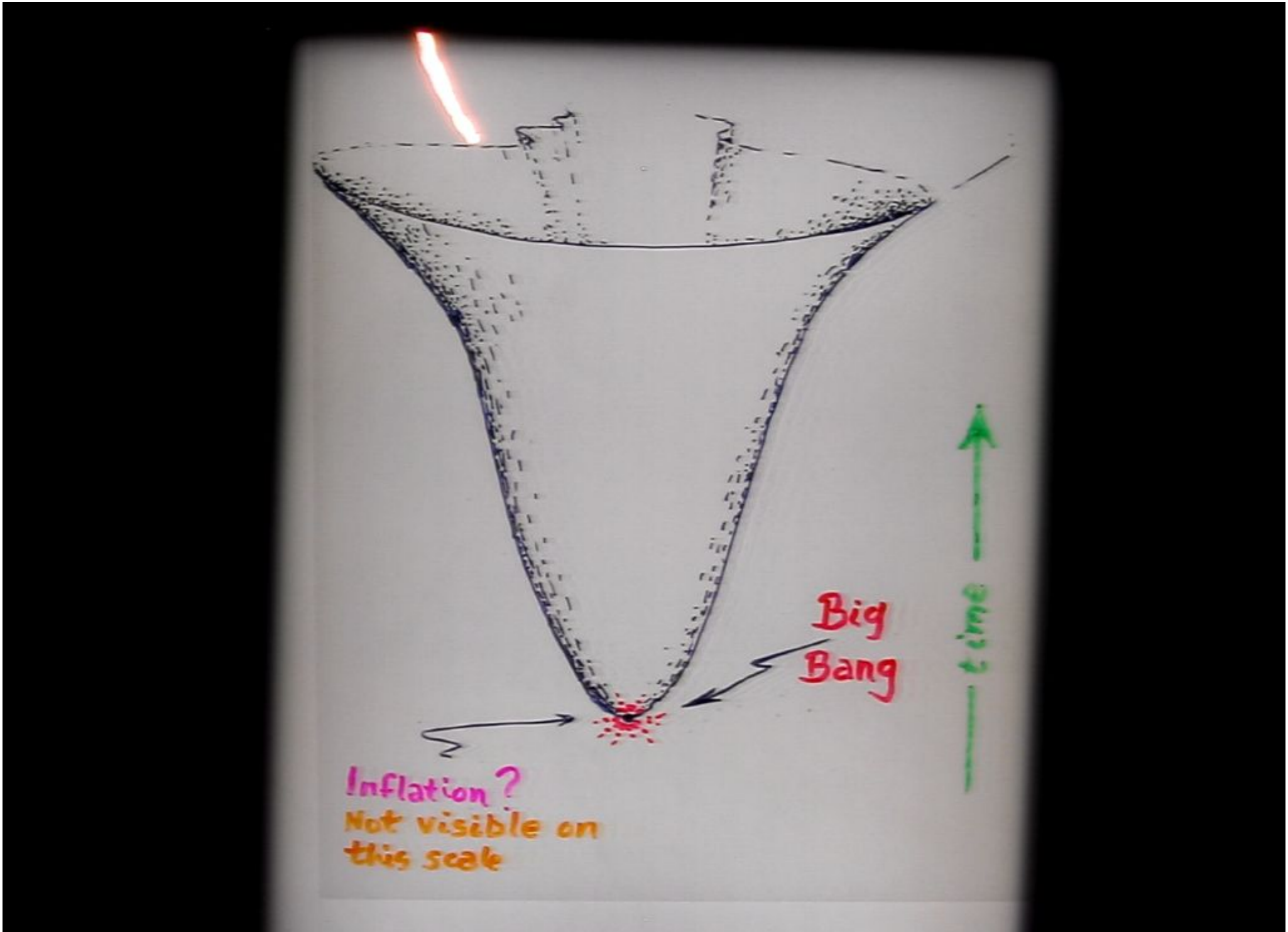
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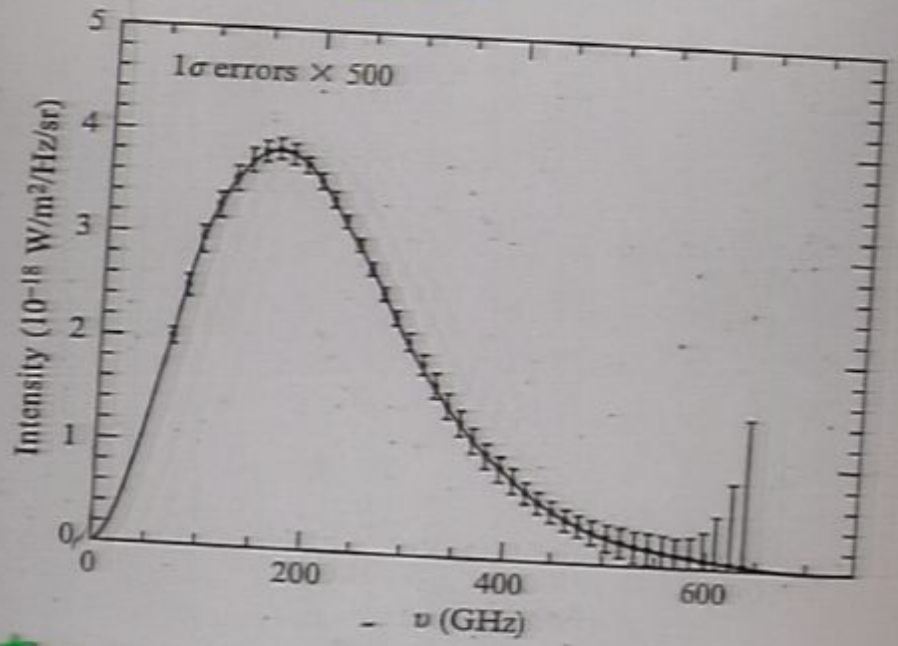
Spectrum of the Cosmic Microwave Background

CMB

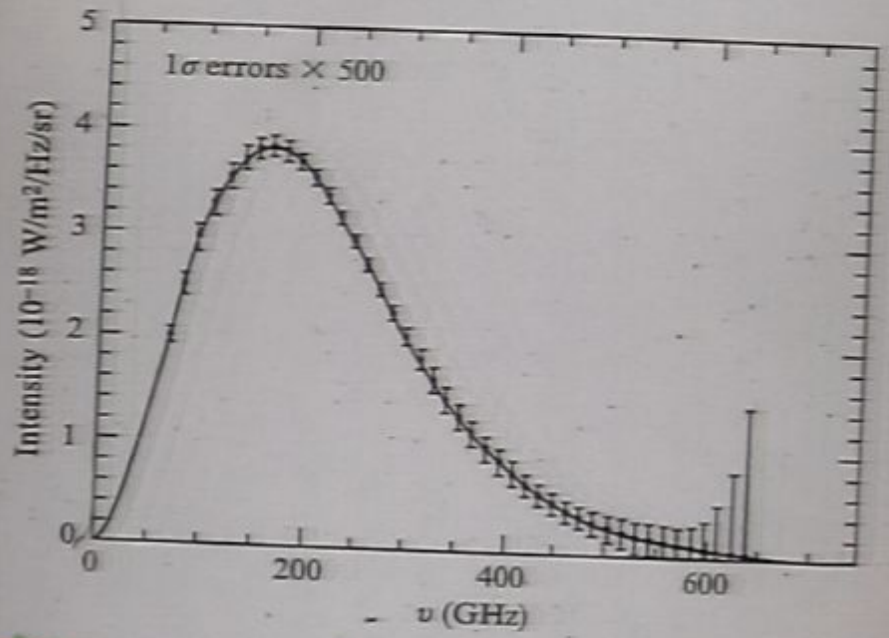


Note: error bars are exaggerated by a factor of 500.

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

Spectrum of the Cosmic Microwave Background

CMB



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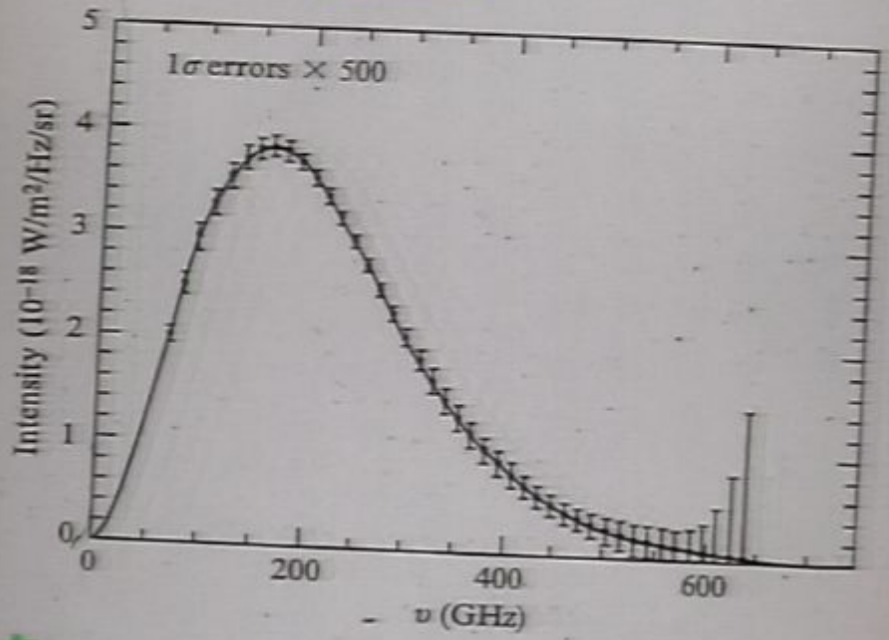
Spectrum of the Cosmic Microwave Background

CMB



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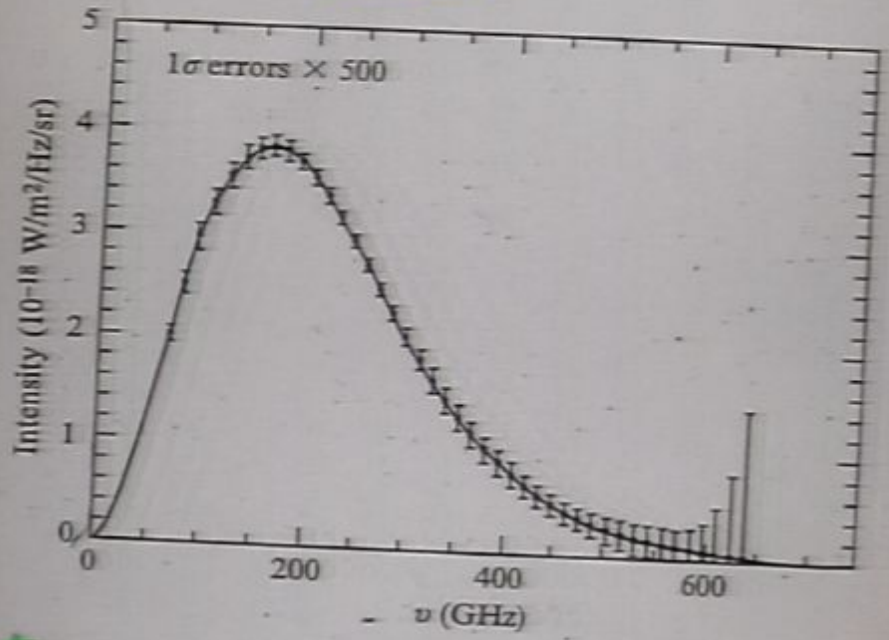

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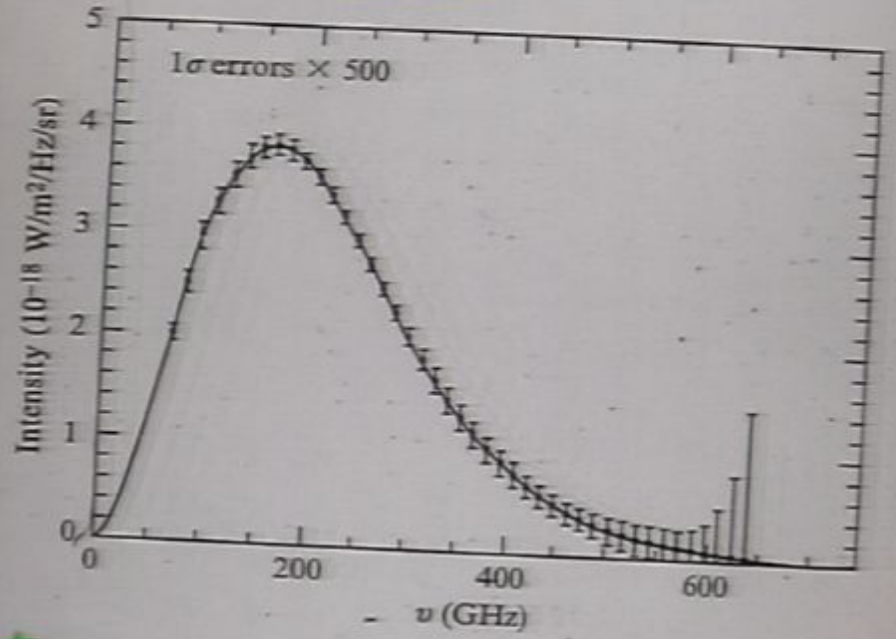

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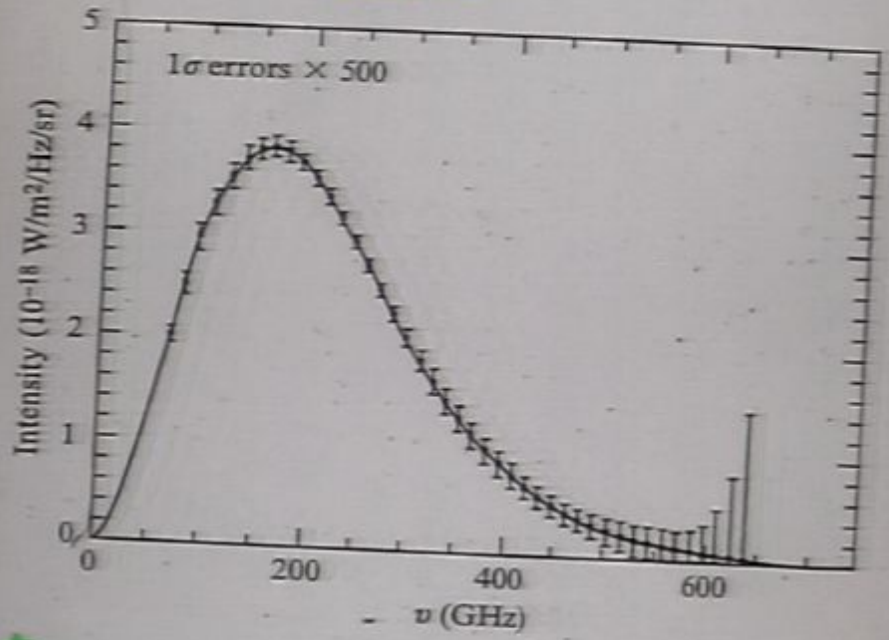

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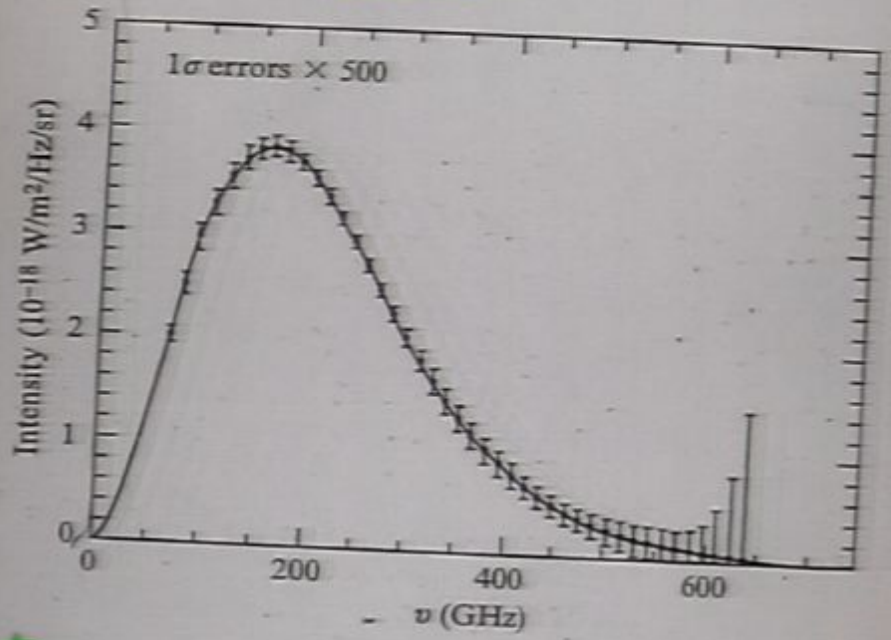

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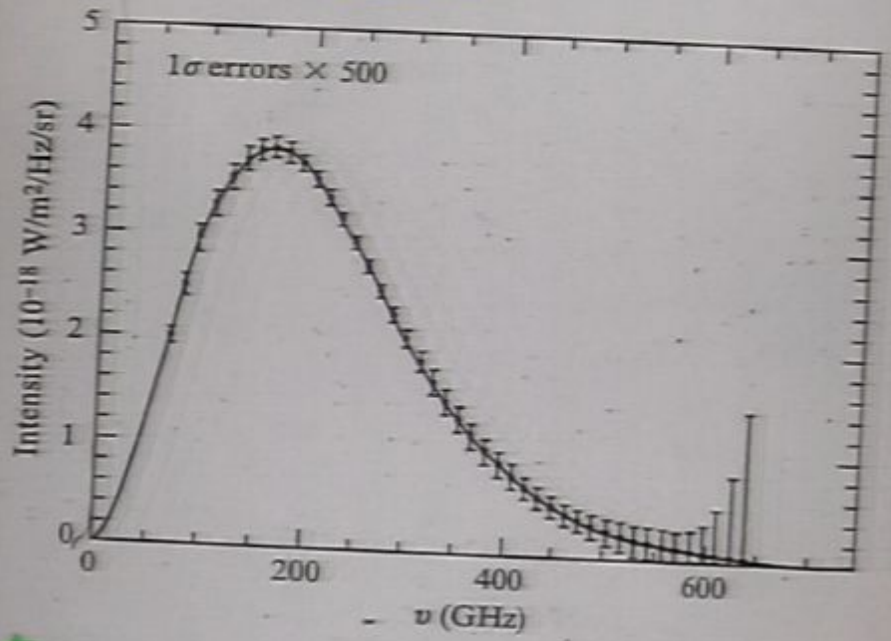

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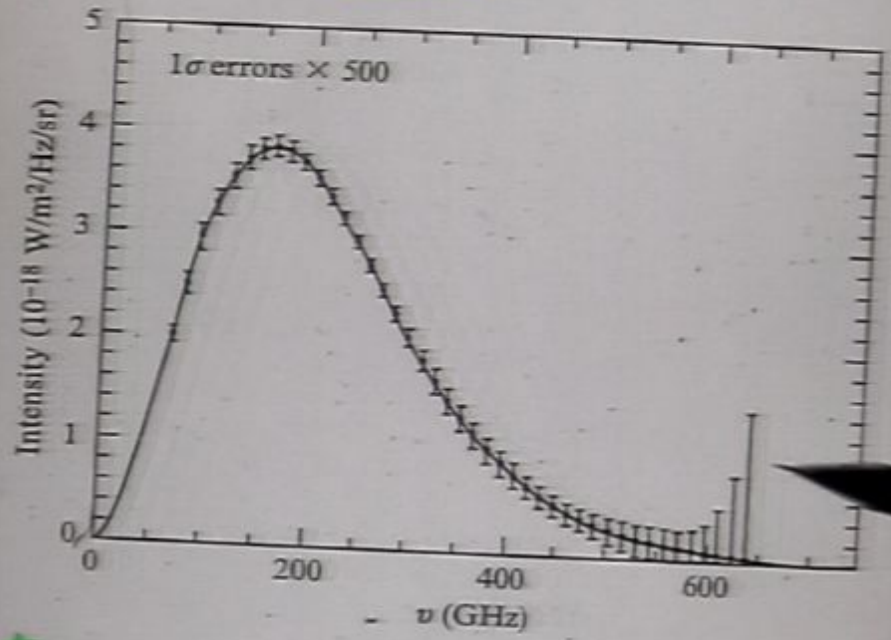

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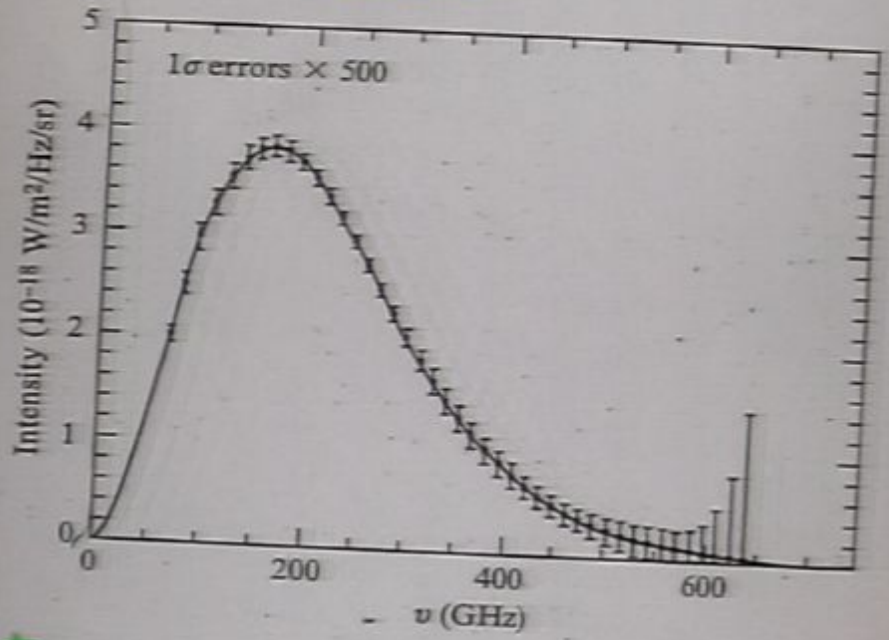

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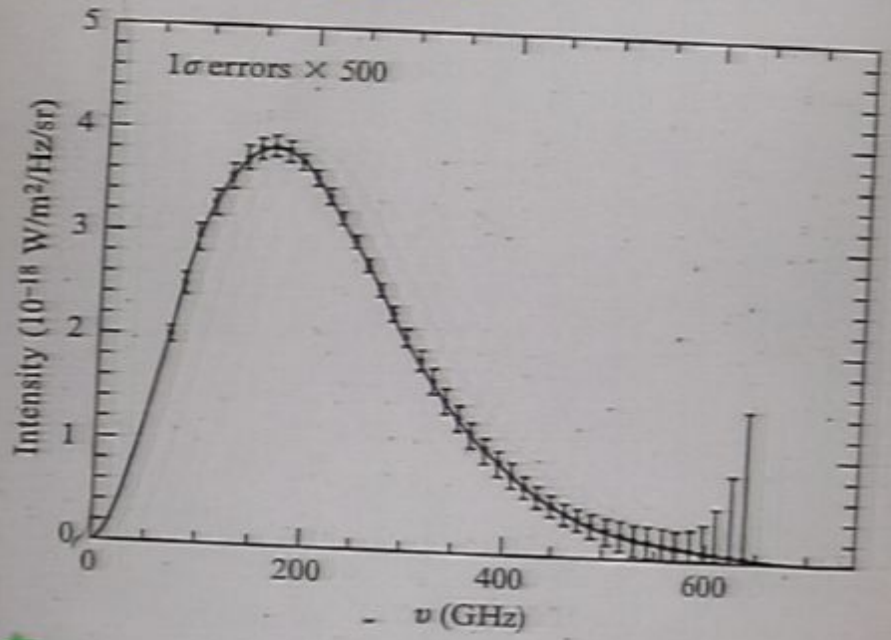

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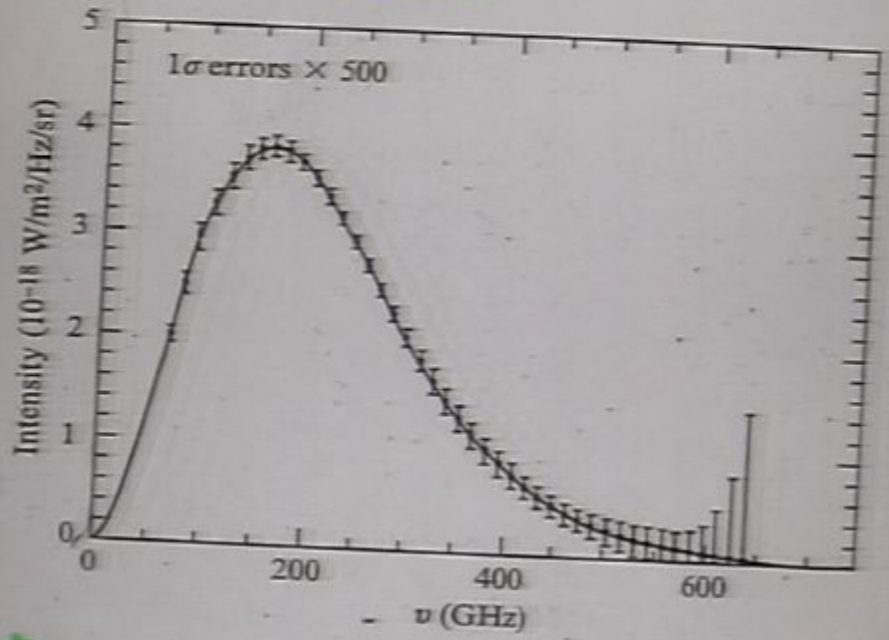

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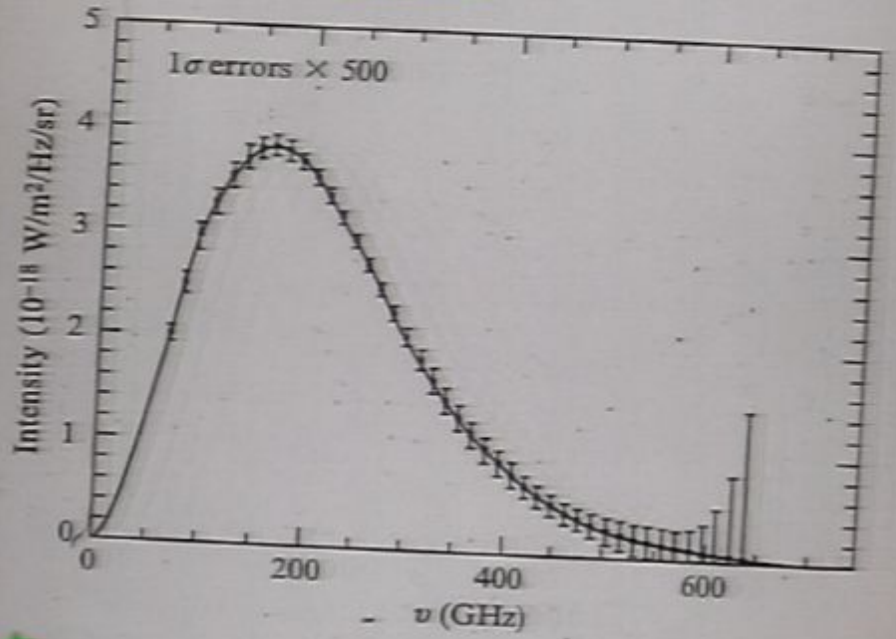

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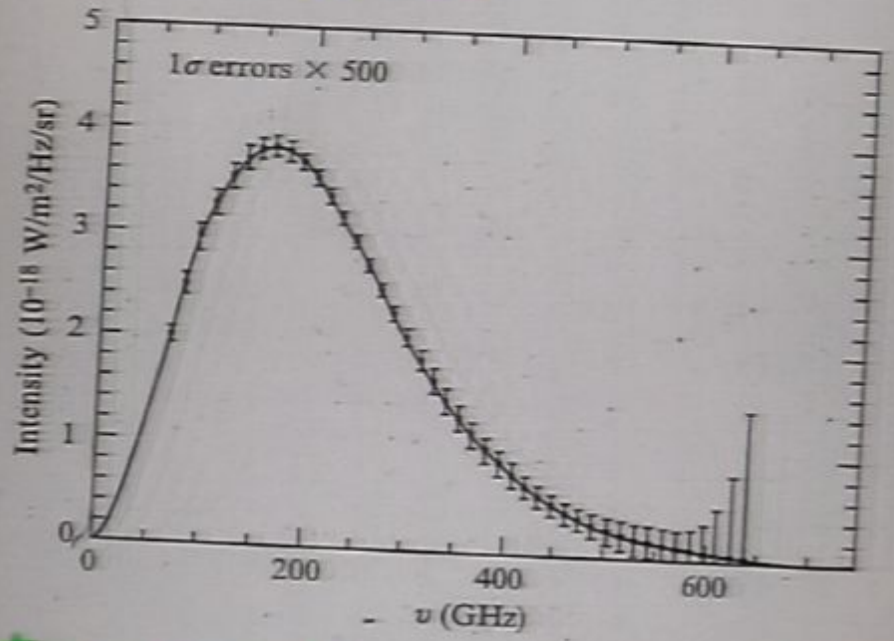

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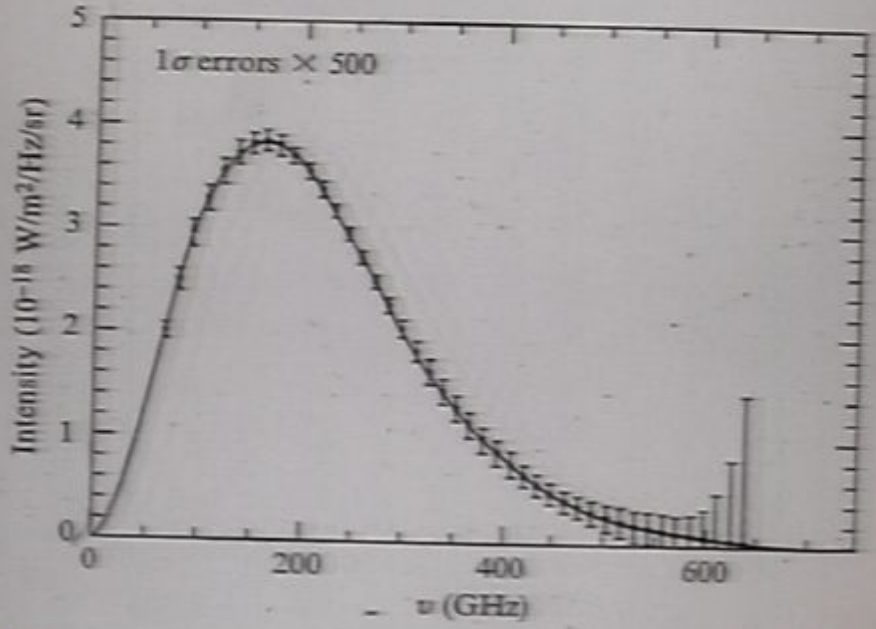

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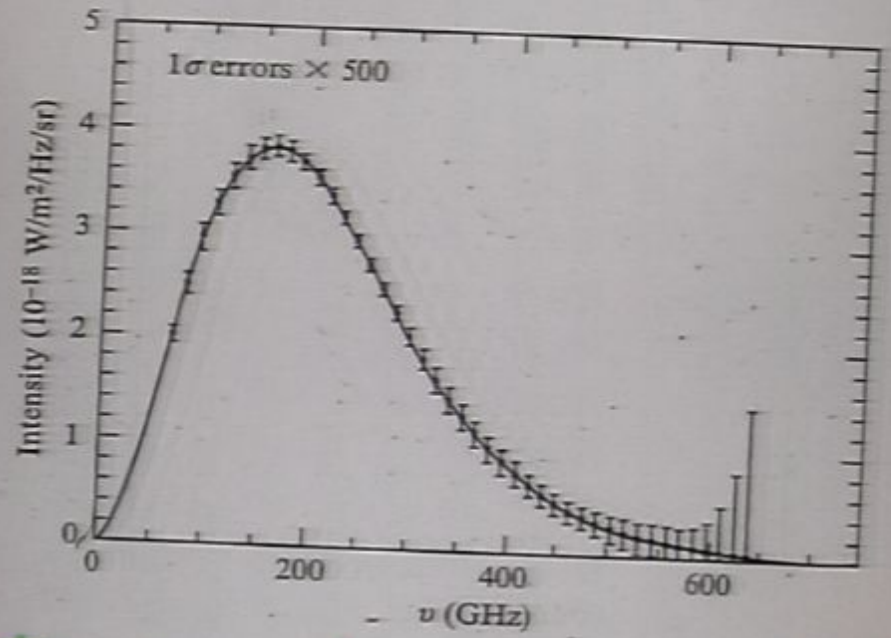

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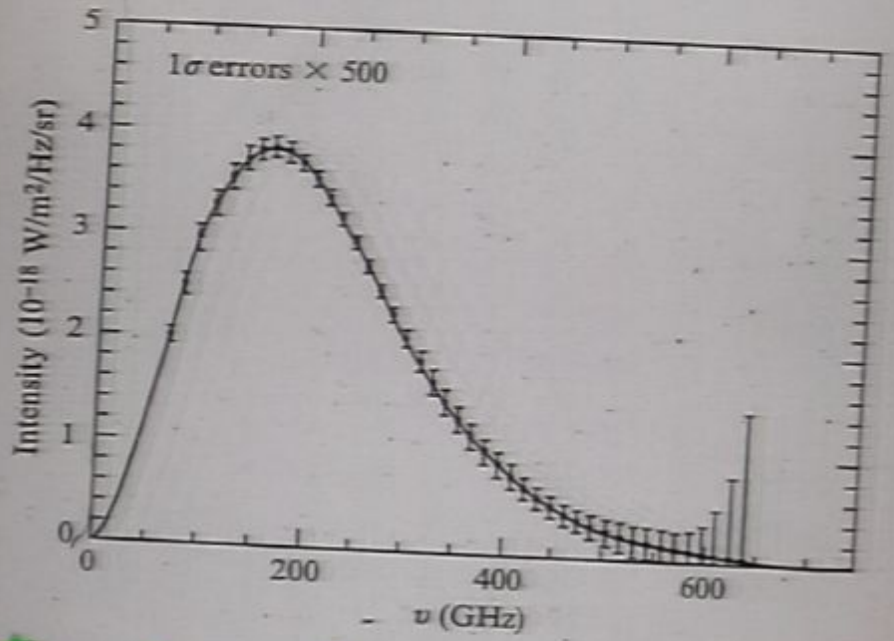

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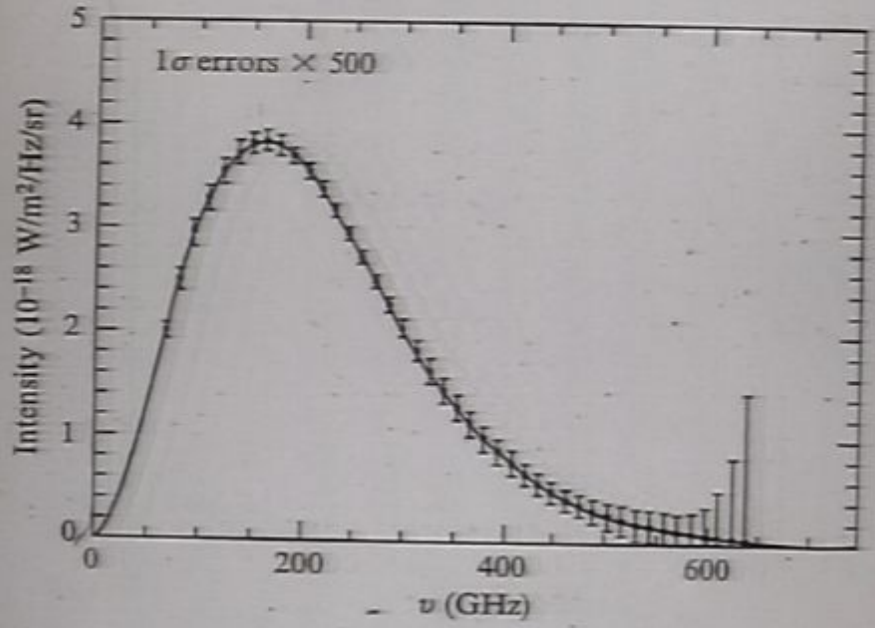

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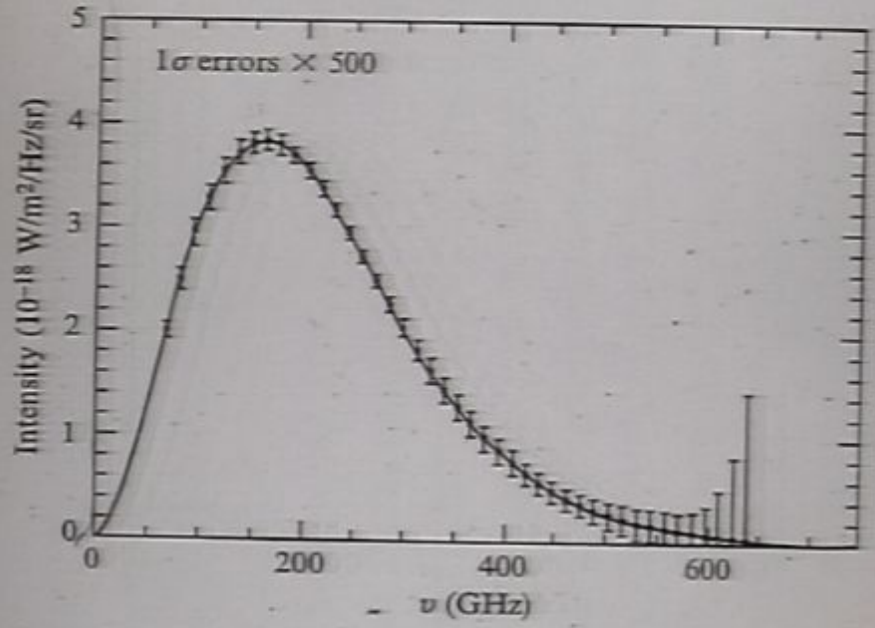
Spectrum of the Cosmic Microwave Background

CMB



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

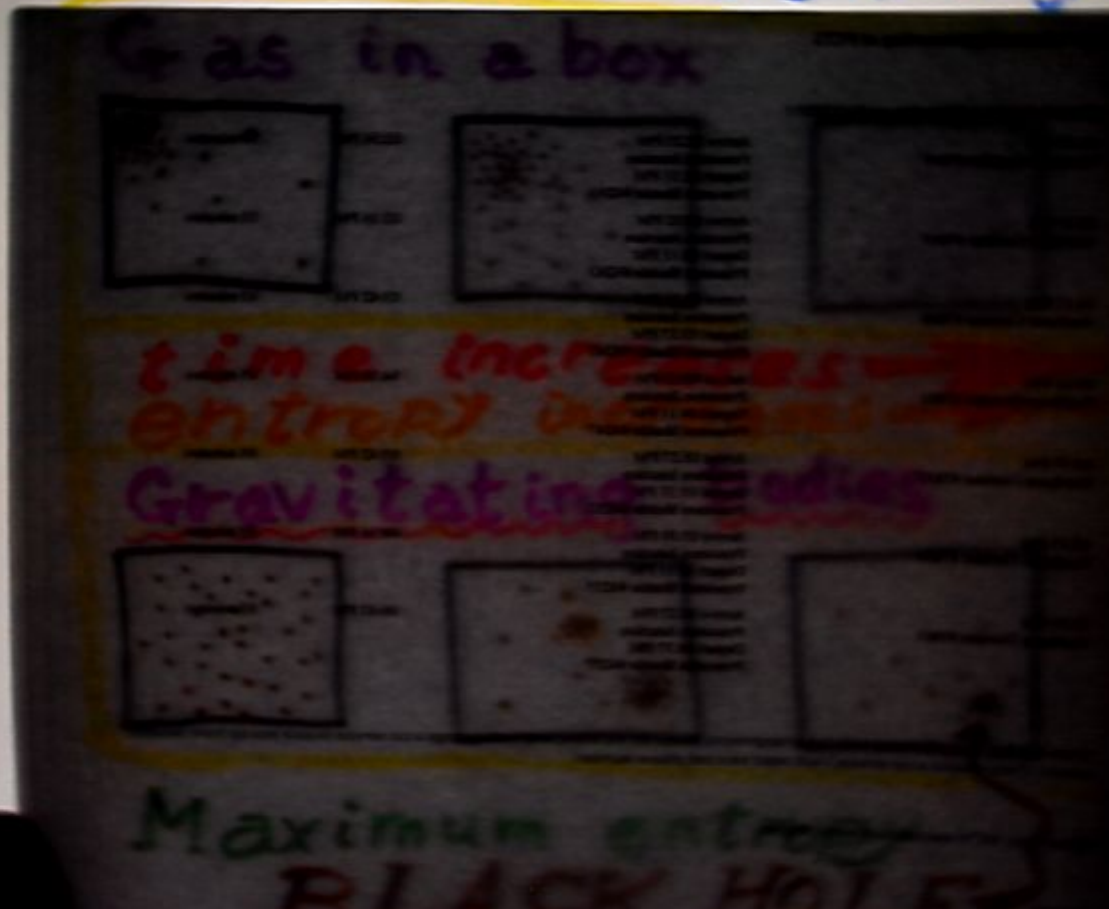
The solid curve displays the Planck black body spectrum of *thermal equilibrium*.



2nd Law of Thermodynamics

Entropy increases with time

↗ = "disorder" (roughly speaking)



2nd Law of Thermodynamics

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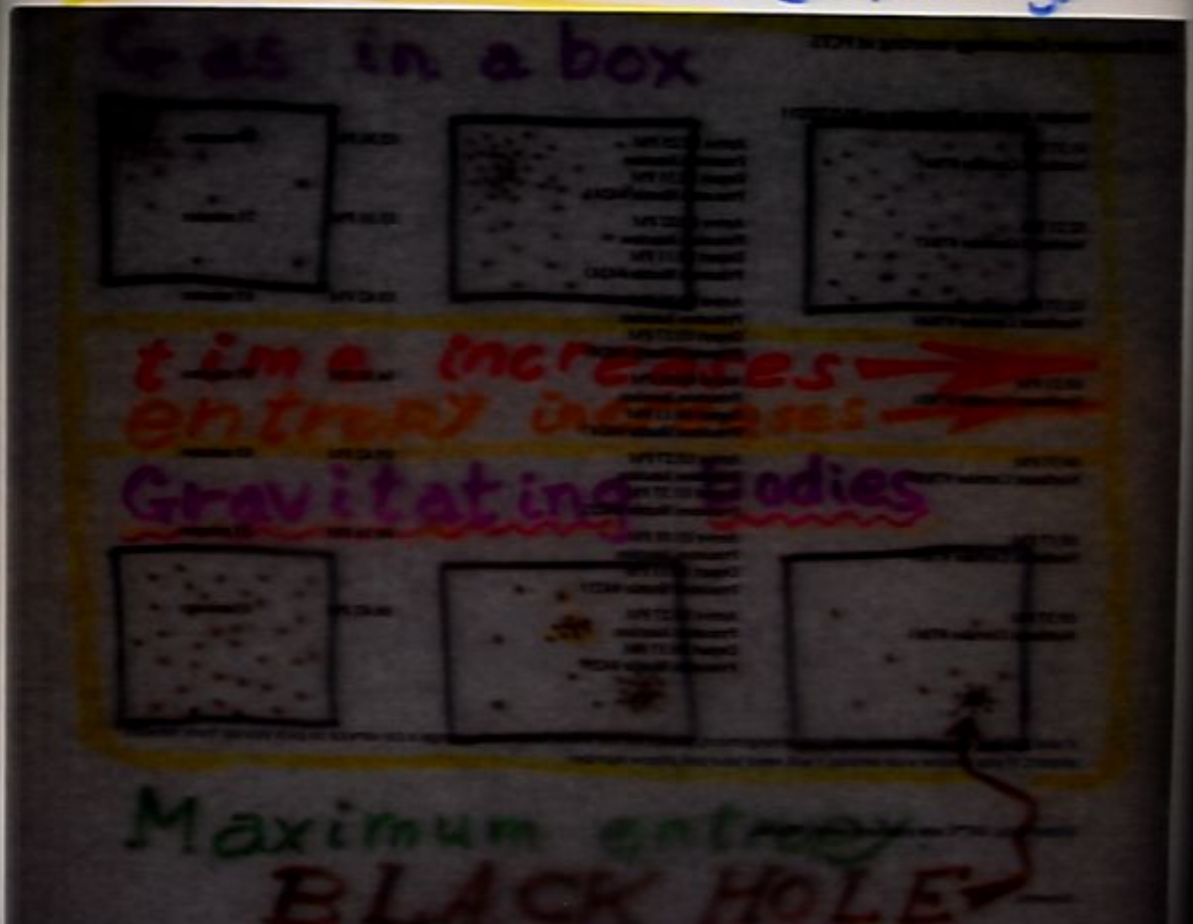


2nd Law of Thermodynamics

Entropy increases with time

= "disorder" (roughly speaking)

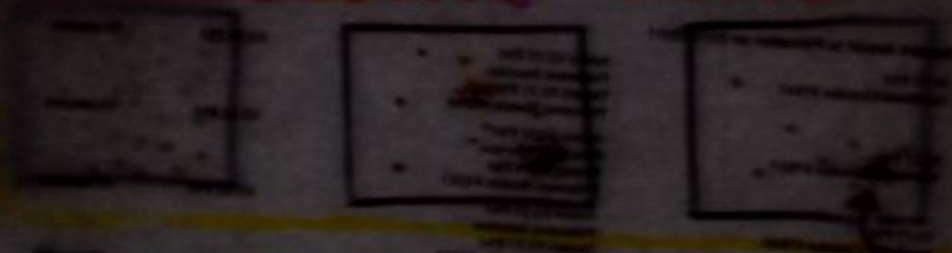
Gas in a box



time increases →

entropy increases →

rotating bodies



Maximum entropy

BLACK HOLE

2nd Law of Thermodynamics

Entropy increases with time

↑ = "disorder" (roughly speaking)

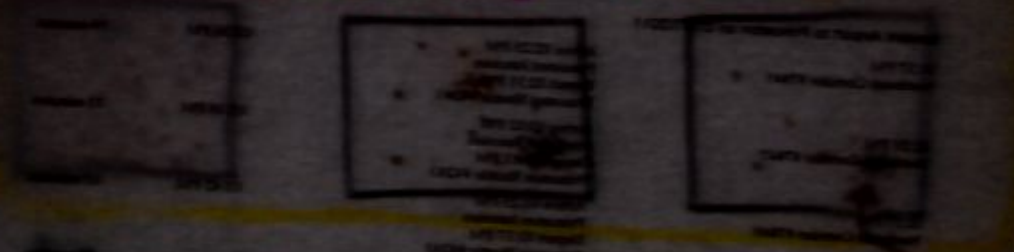
Gas in a box



time increases →

entropy increases →

[illegible]



Maximum entropy

BLACK HOLE

2nd Law of Thermodynamics

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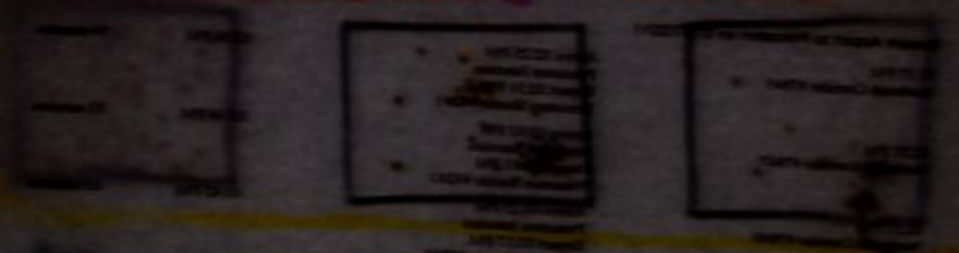
Gas in a box



time increases →

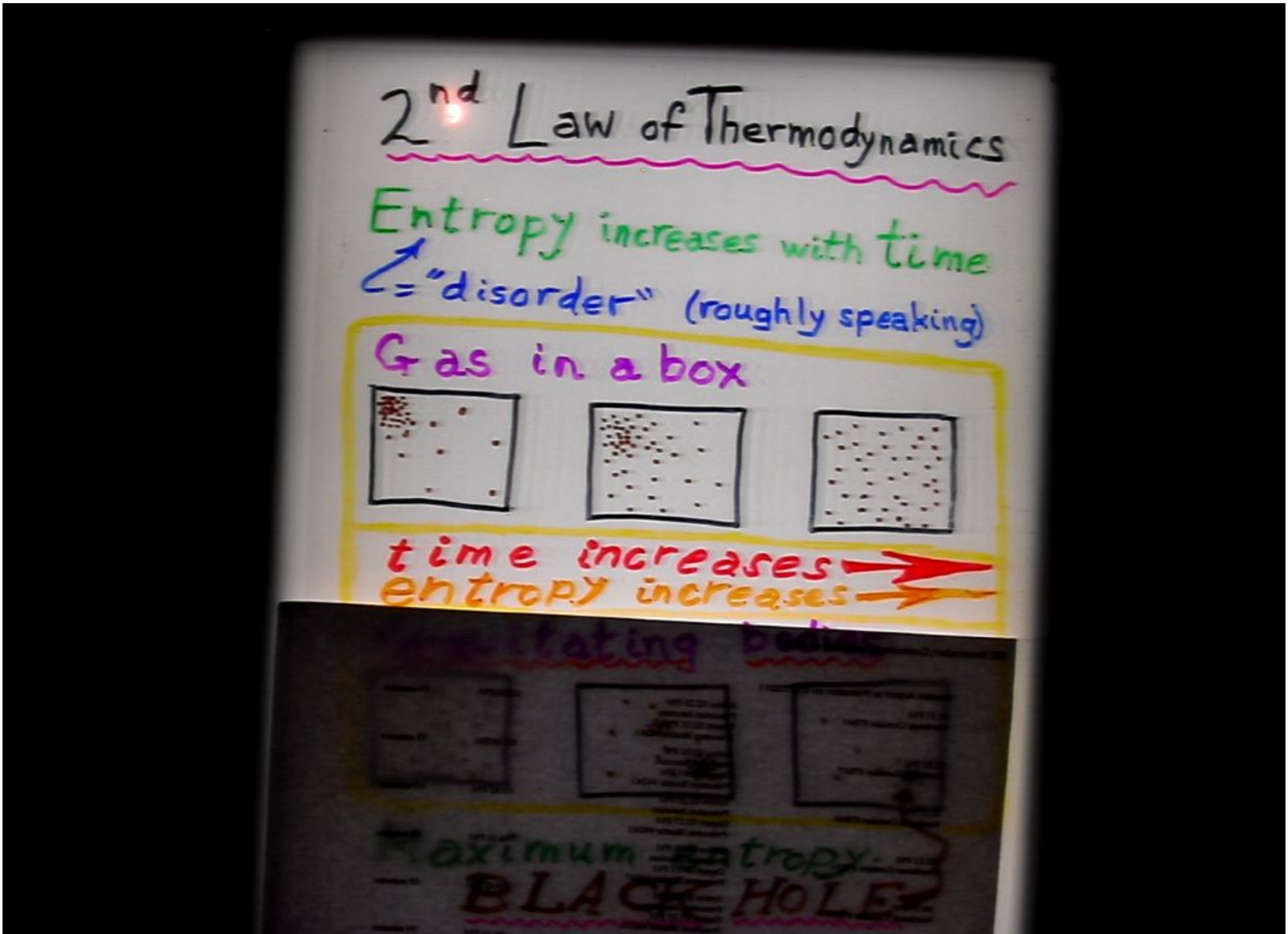
entropy increases →

Rotating body



Maximum entropy

BLACK HOLE


2nd Law of Thermodynamics
Entropy increases with time
= "disorder" (roughly speaking)
Gas in a box
time increases
entropy increases
Maximum entropy
BLACK HOLE

2nd Law of Thermodynamics

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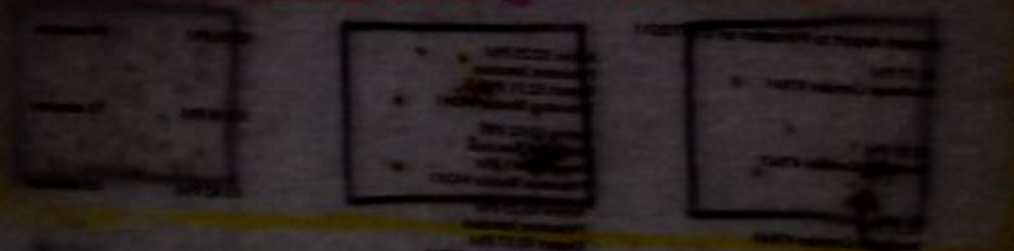
Gas in a box



time increases →

entropy increases →



Maximum entropy

BLACK HOLE

2nd Law of Thermodynamics

Entropy increases with time

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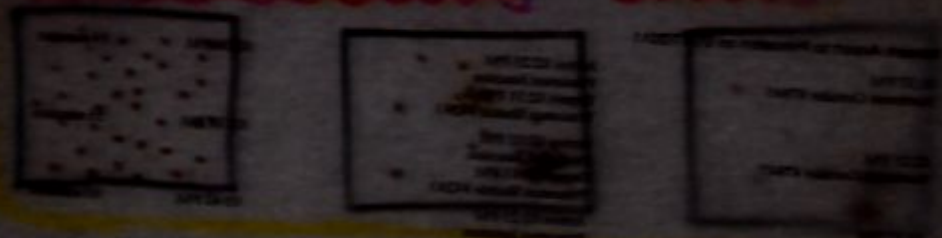
Gas in a box



time increases →

entropy increases →

Gravitating bodies



Maximum entropy

BLACK HOLE

2nd Law of Thermodynamics

Entropy increases with time

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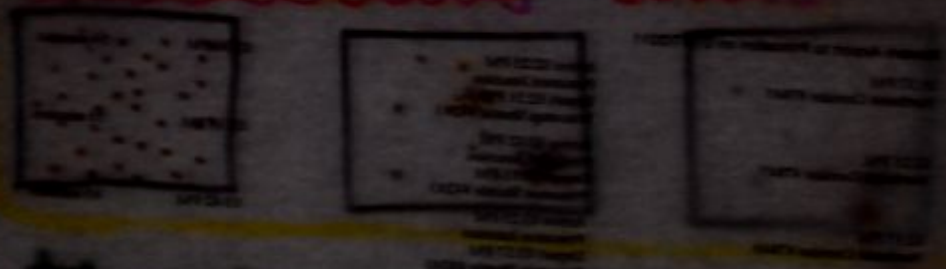
Gas in a box



time increases →

entropy increases →

Gravitating particles



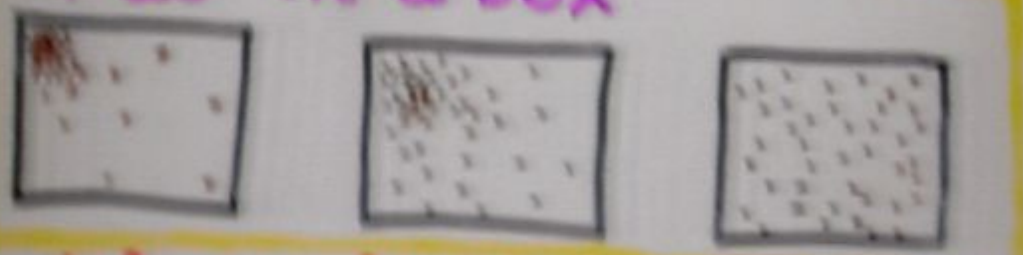
Maximum [illegible]

BLACK [illegible]

Entropy increases with time

= "disorder" (roughly speaking)

Gas in a box



time increases
entropy increases

Gravitating bodies



Maximum entropy:
BLACK HOLE

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

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Gravitating bodies



Maximum entropy:

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Gravitating bodies



Maximum entropy:

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Gravitating bodies



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Gravitating bodies



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Gas in a box



time increases →

entropy increases →

Gravitating bodies



Maximum entropy:

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Gas in a box



time in
entropy increases

Gravitating bodies



Maximum entropy:
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Gas in a box



time increases
entropy increases

Gravitating bodies



Maximum entropy:
BLACK HOLE

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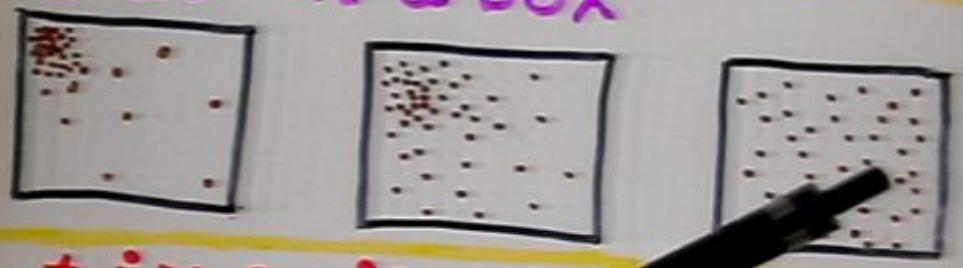
Gas in a box



time increases

entropy increases

Gravitating bodies



Maximum entropy:

BLACK HOLE

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Gas in a box



time increases →

entropy increases →

Gravitating bodies



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Gravitating bodies



Maximum entropy:
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Gravitating bodies



Maximum entropy:
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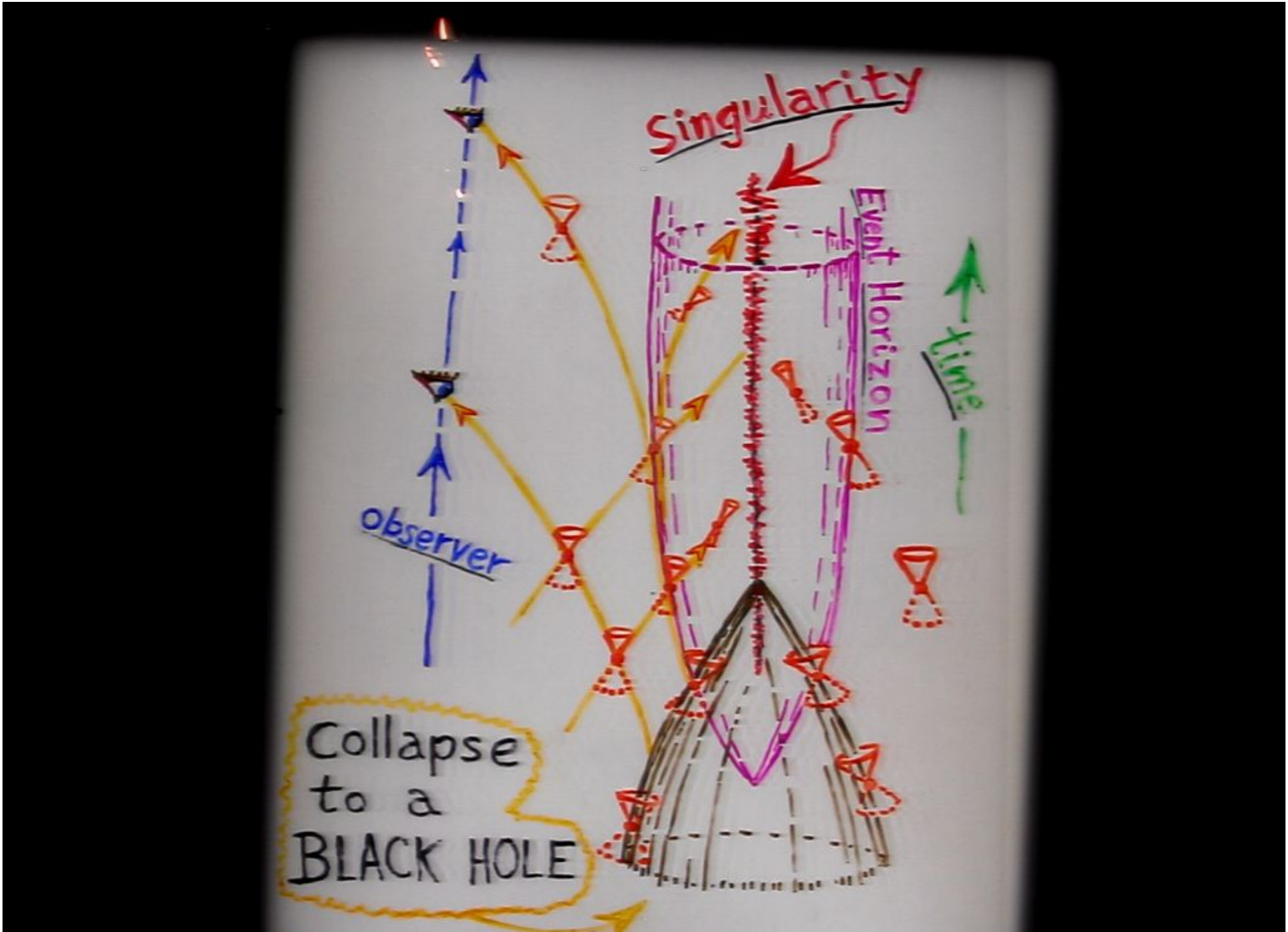
Gravitating bodies



Maximum entropy:

BLACK HOLE




Singularity
Event Horizon
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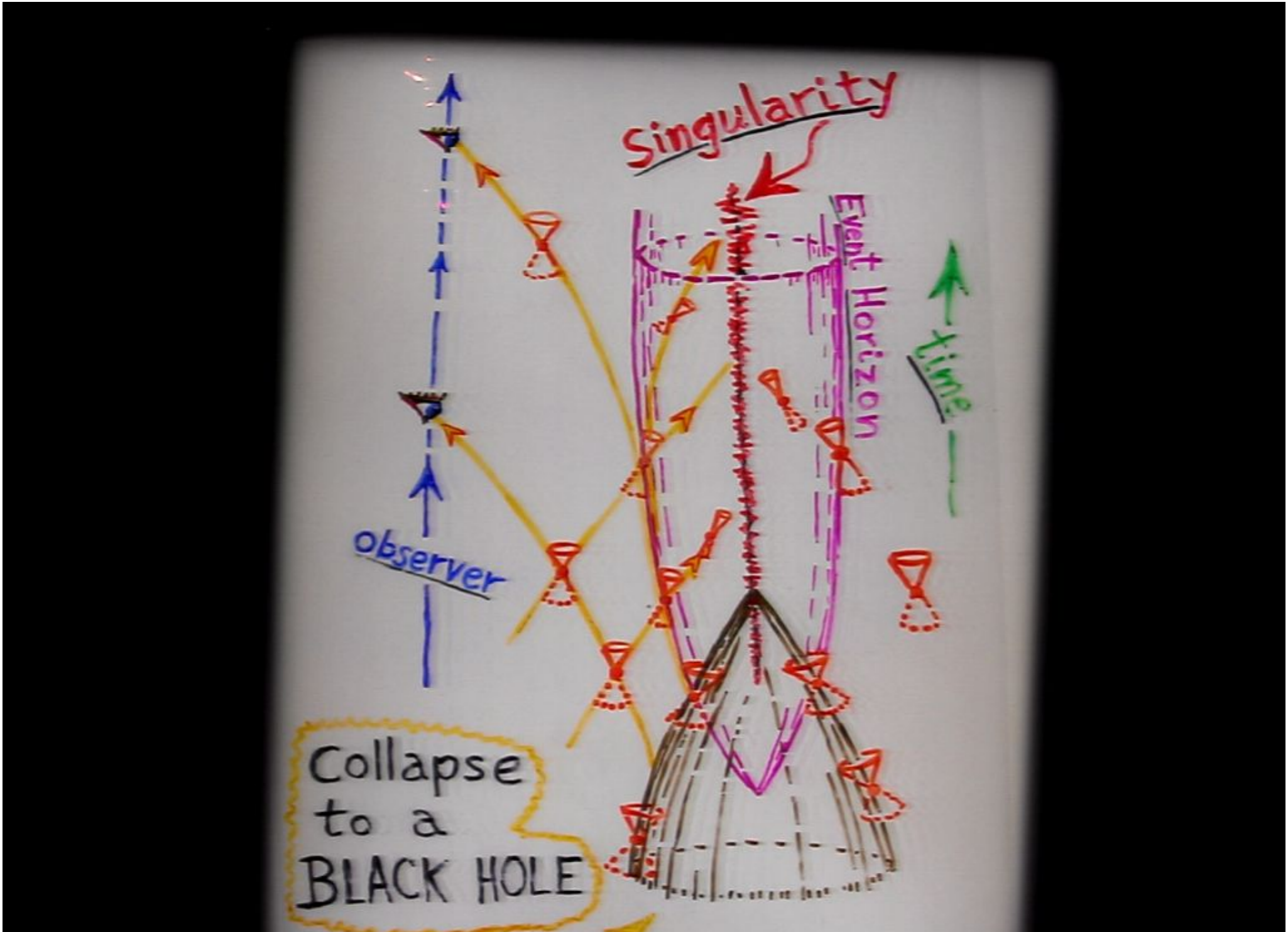
observer
Collapse
to a
BLACK HOLE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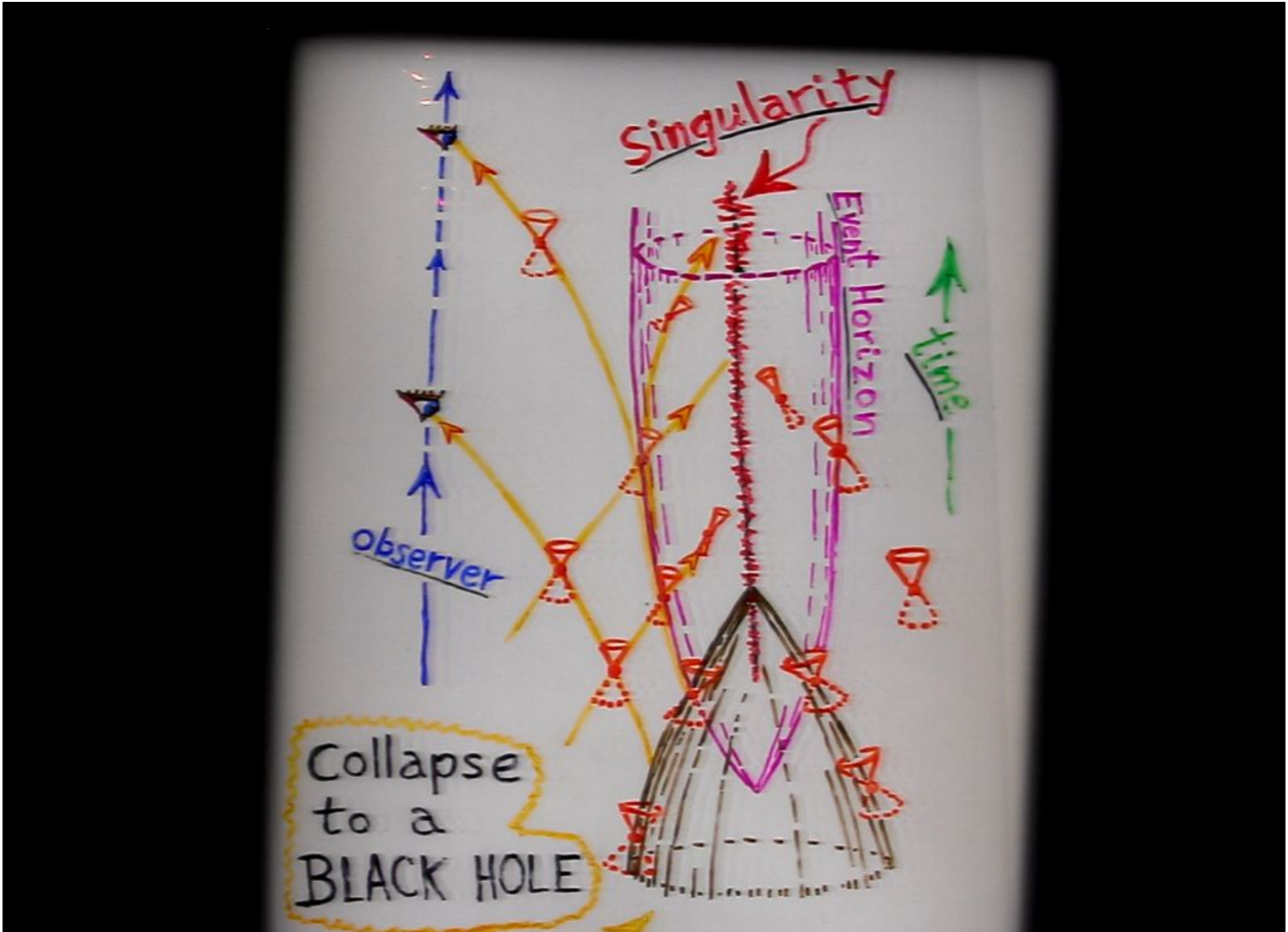
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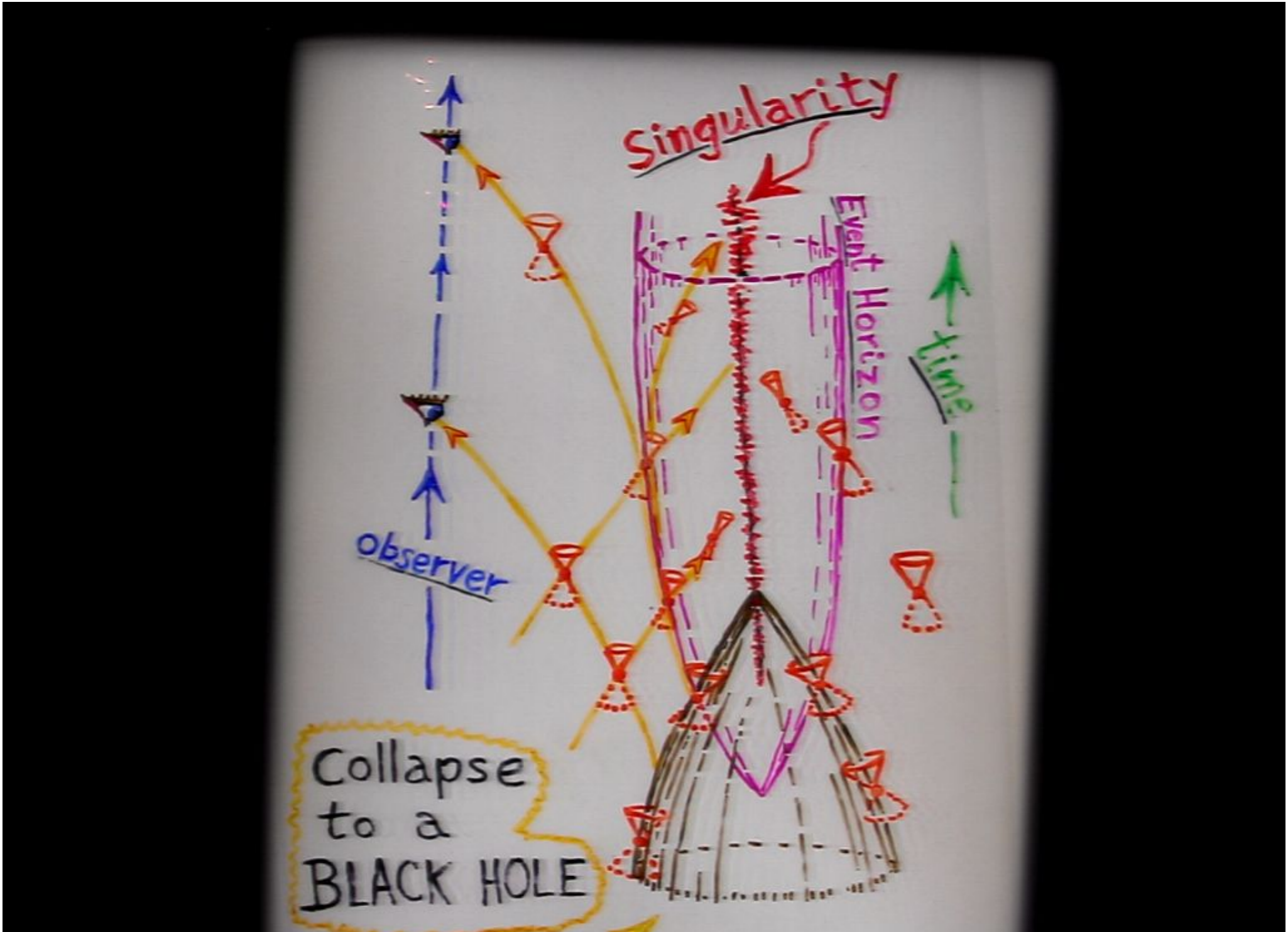
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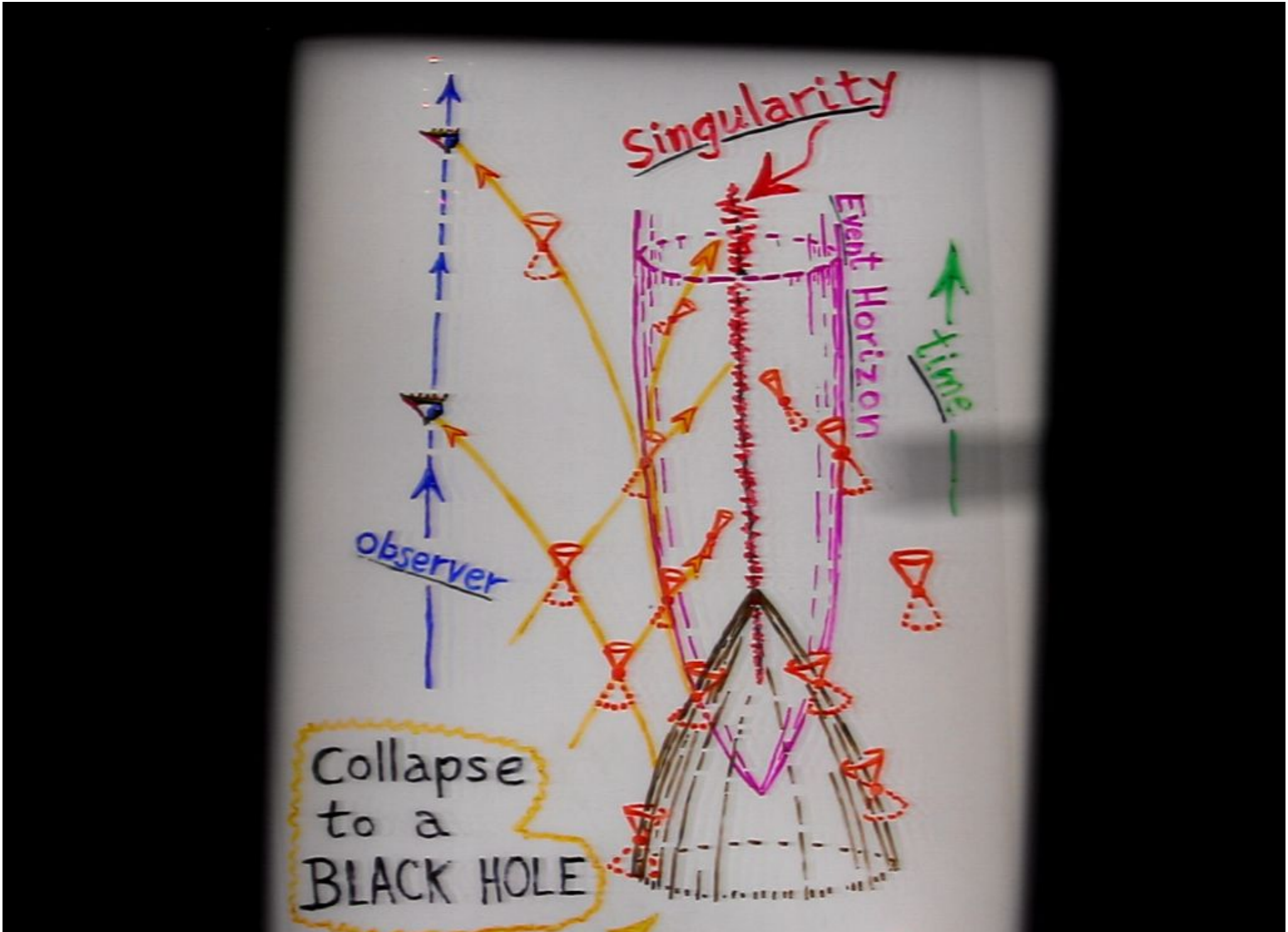
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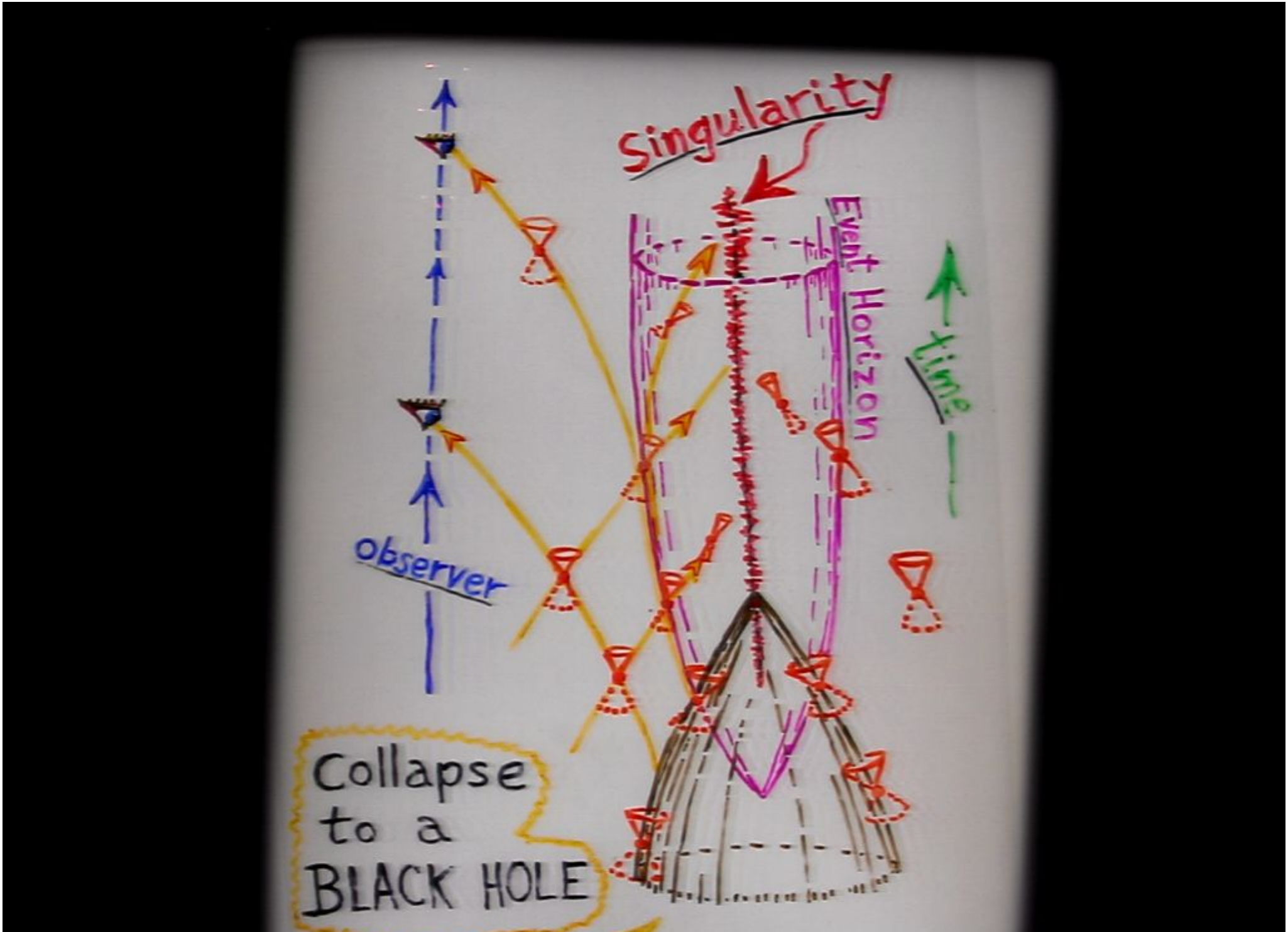
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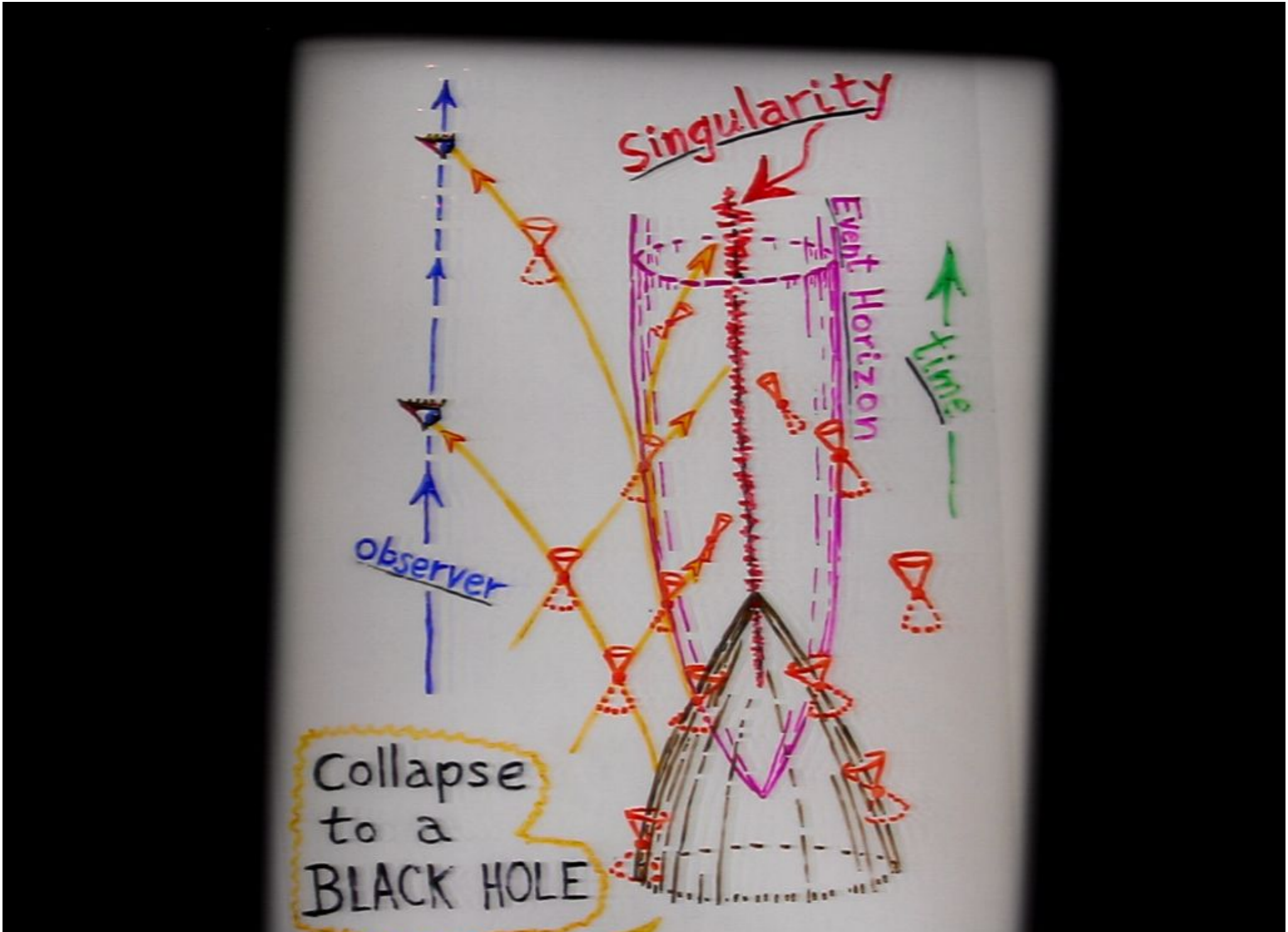
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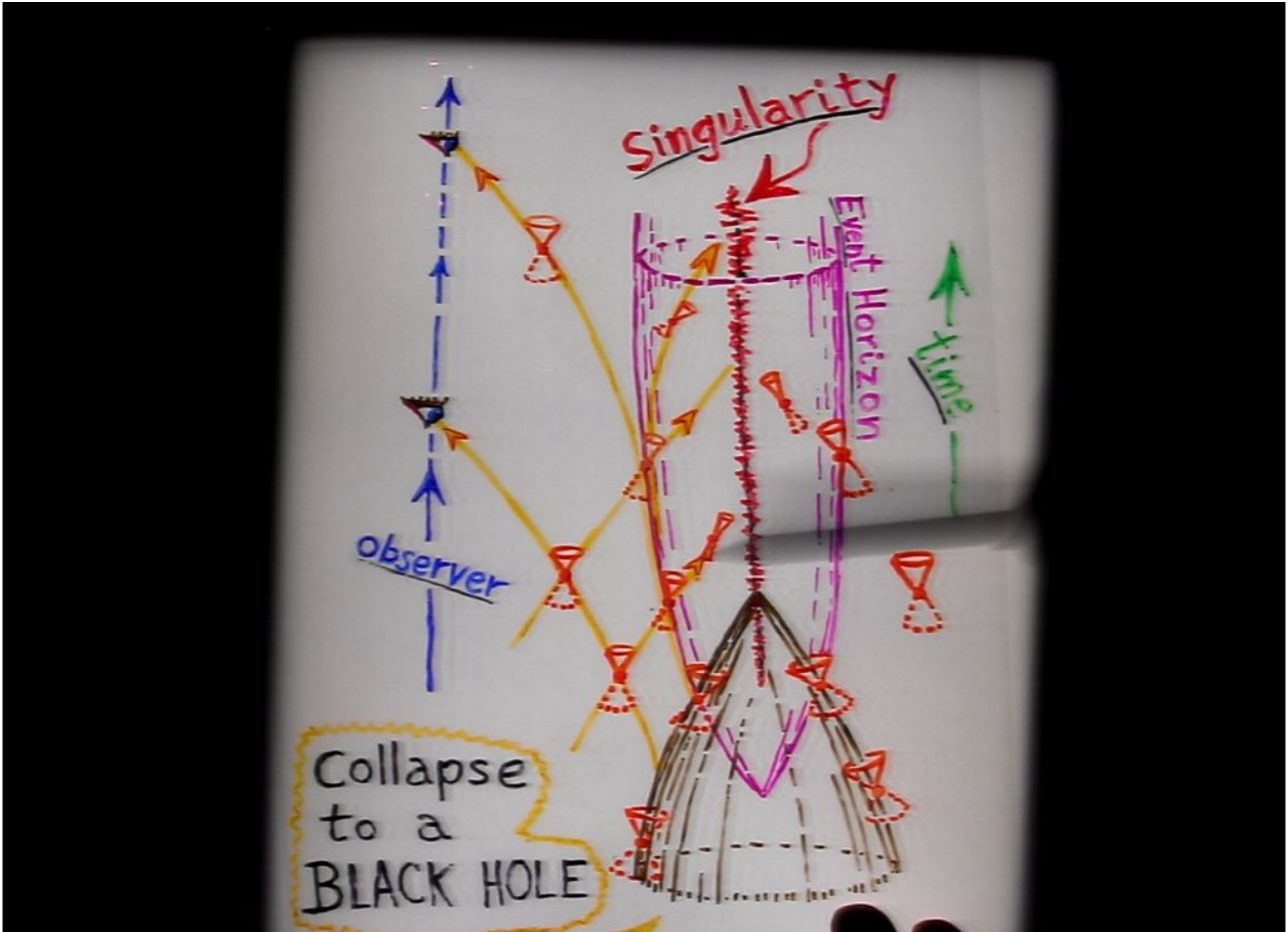
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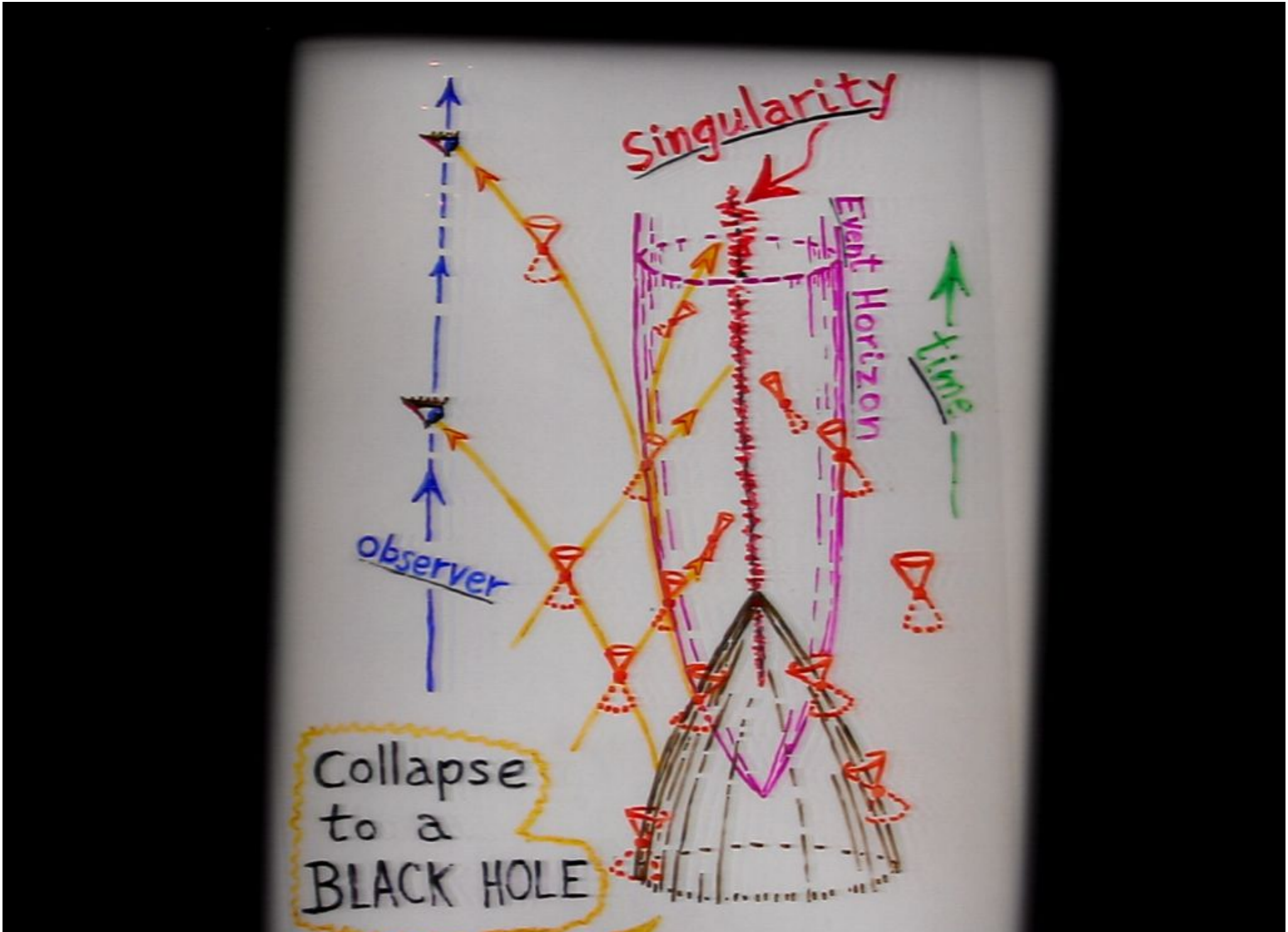
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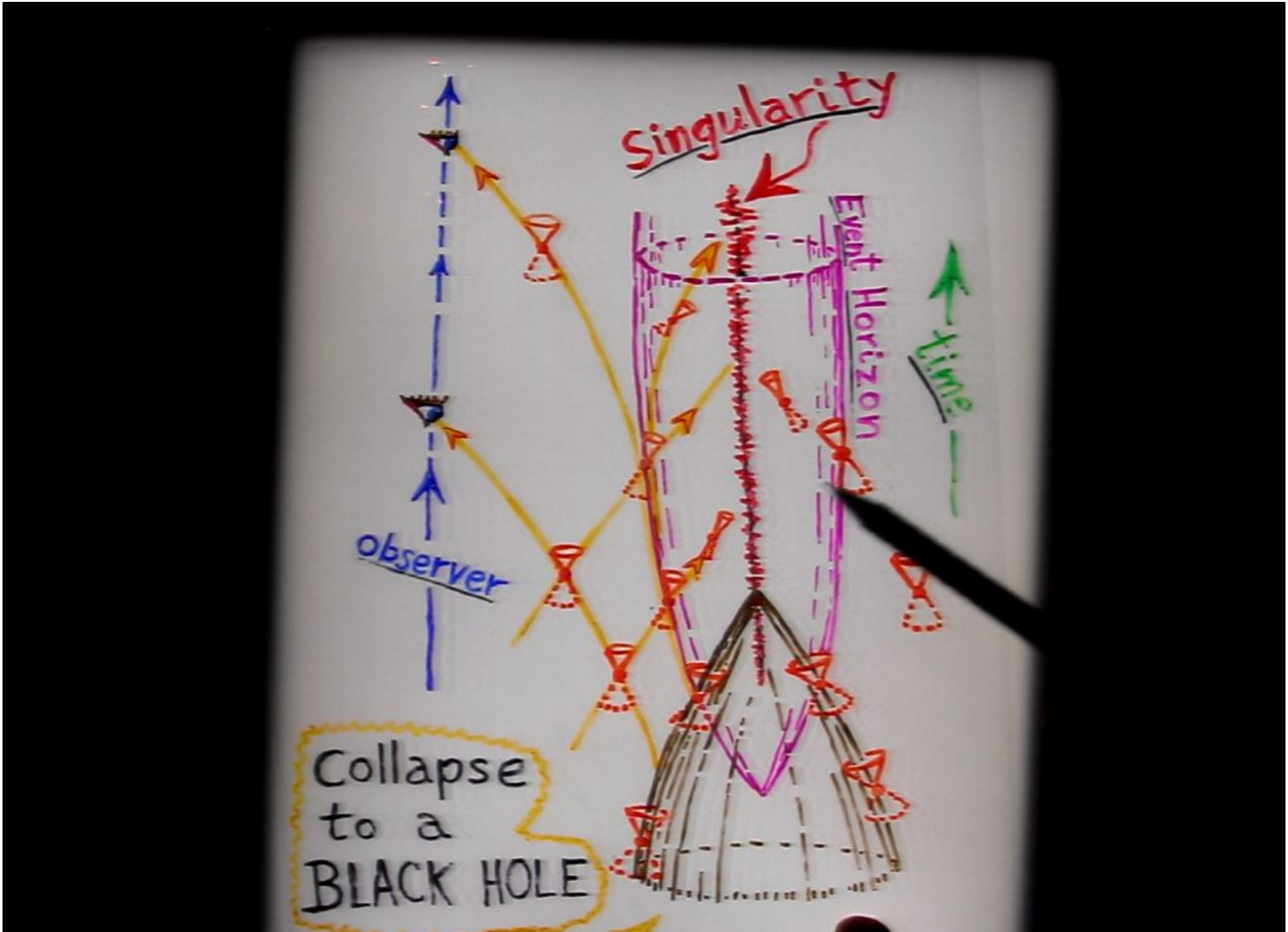
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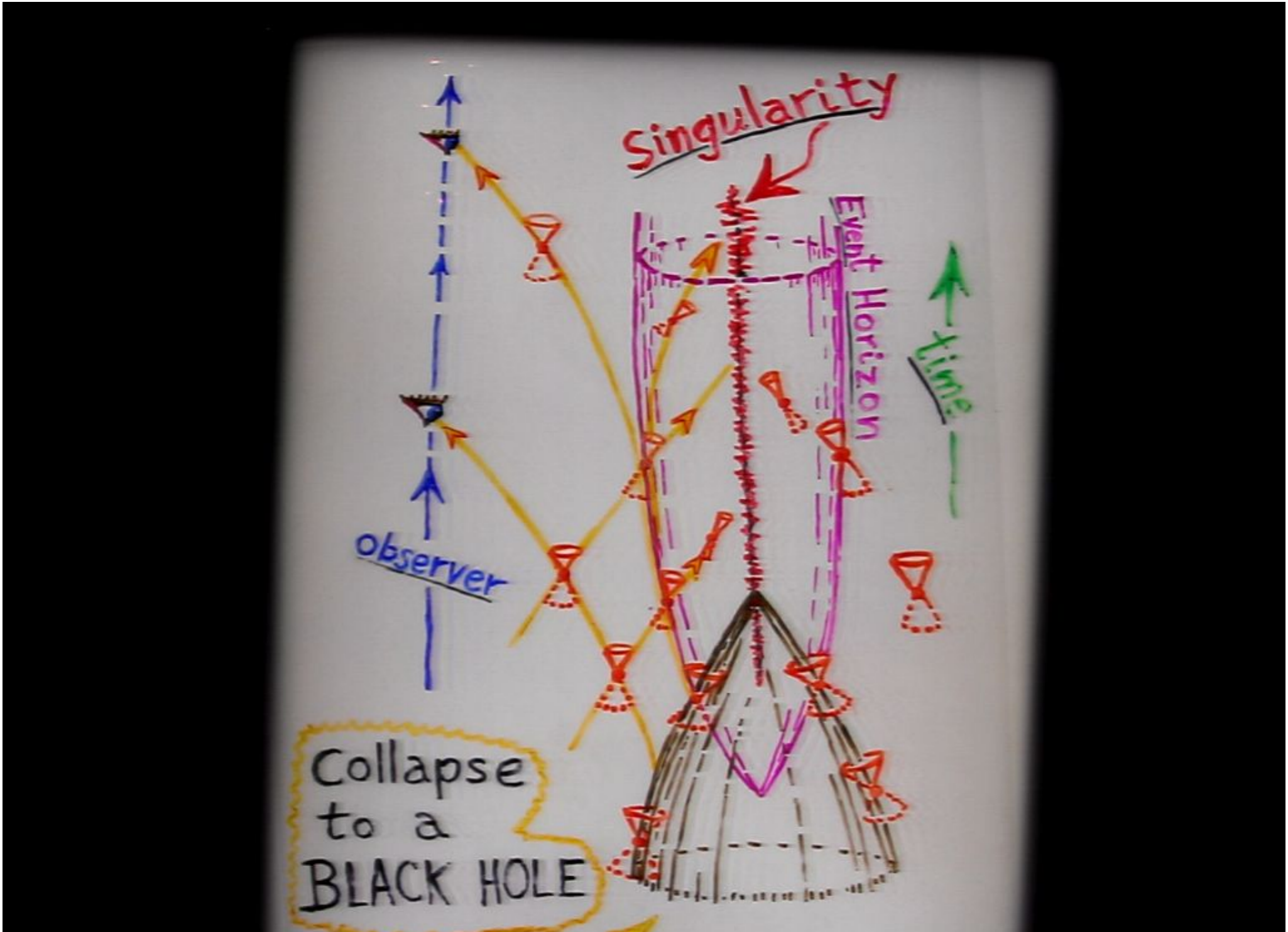
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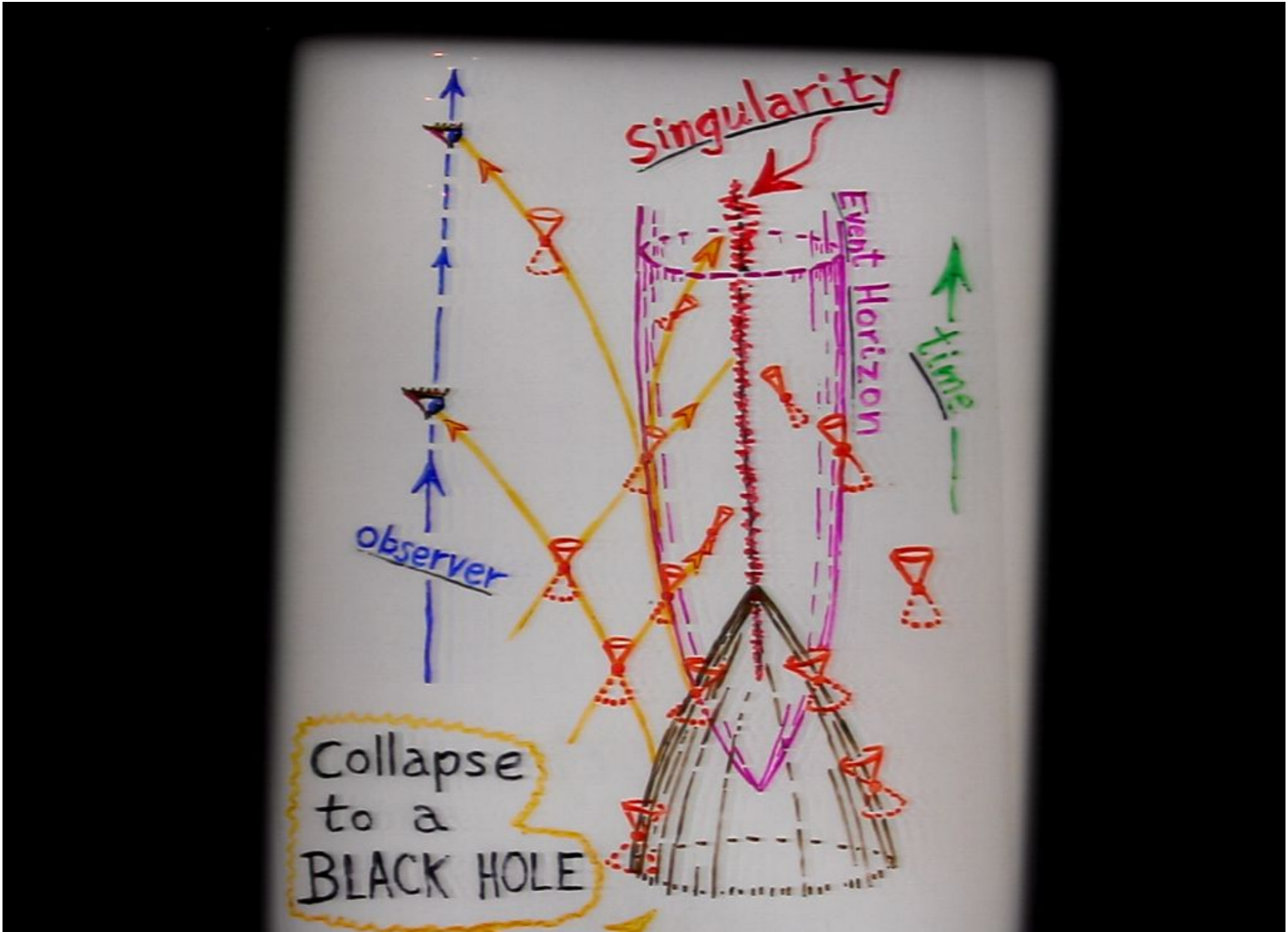
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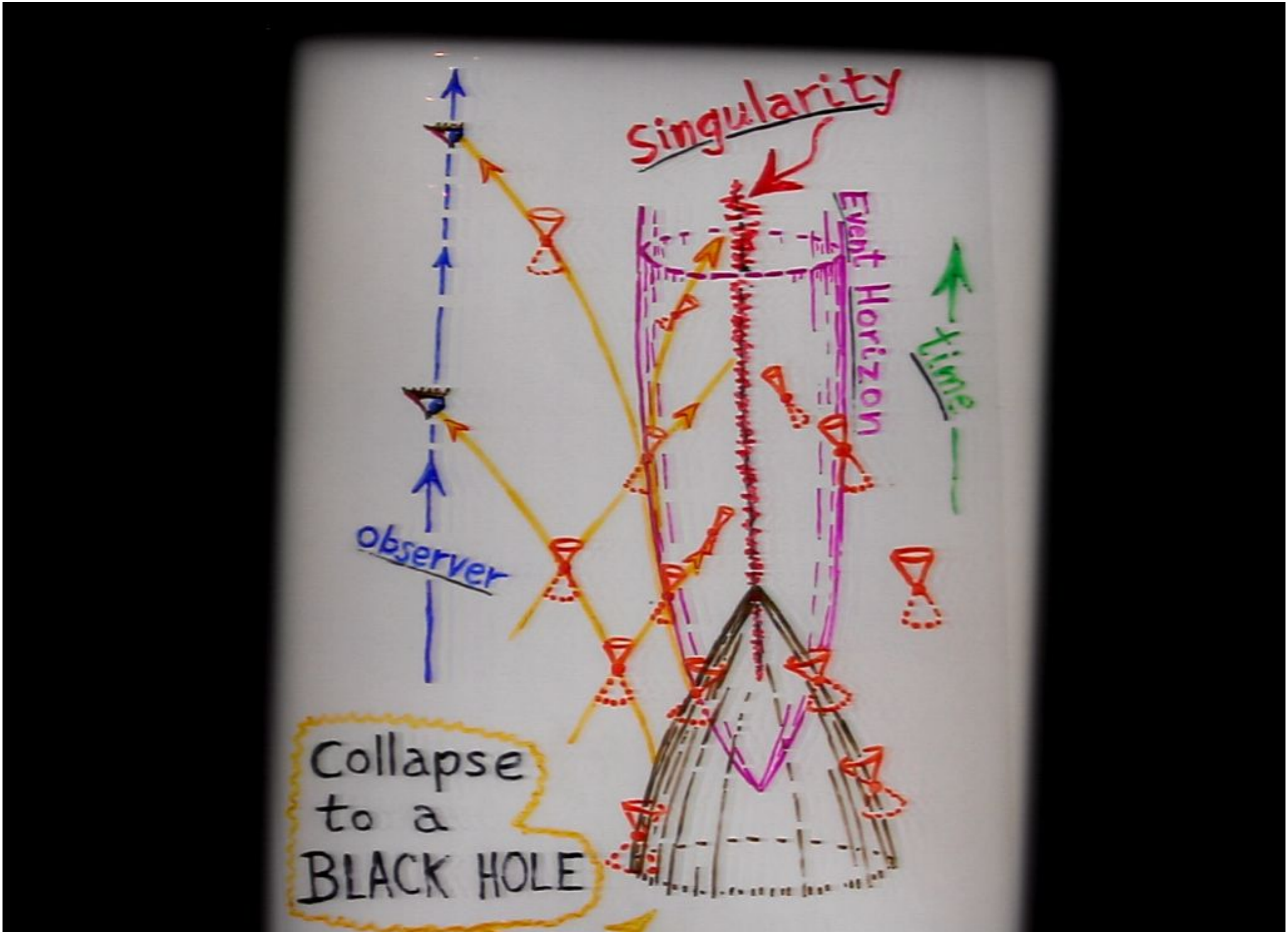
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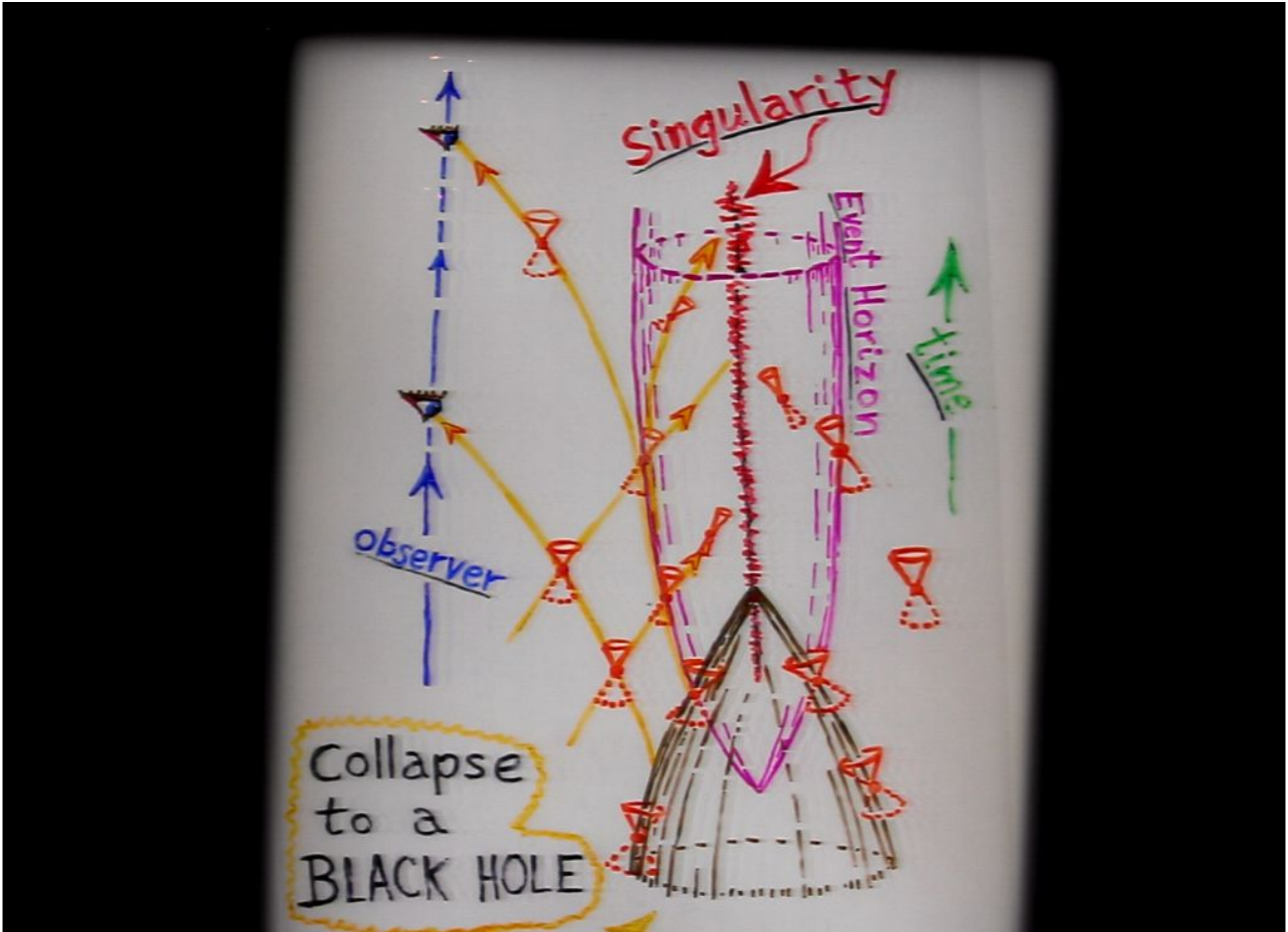
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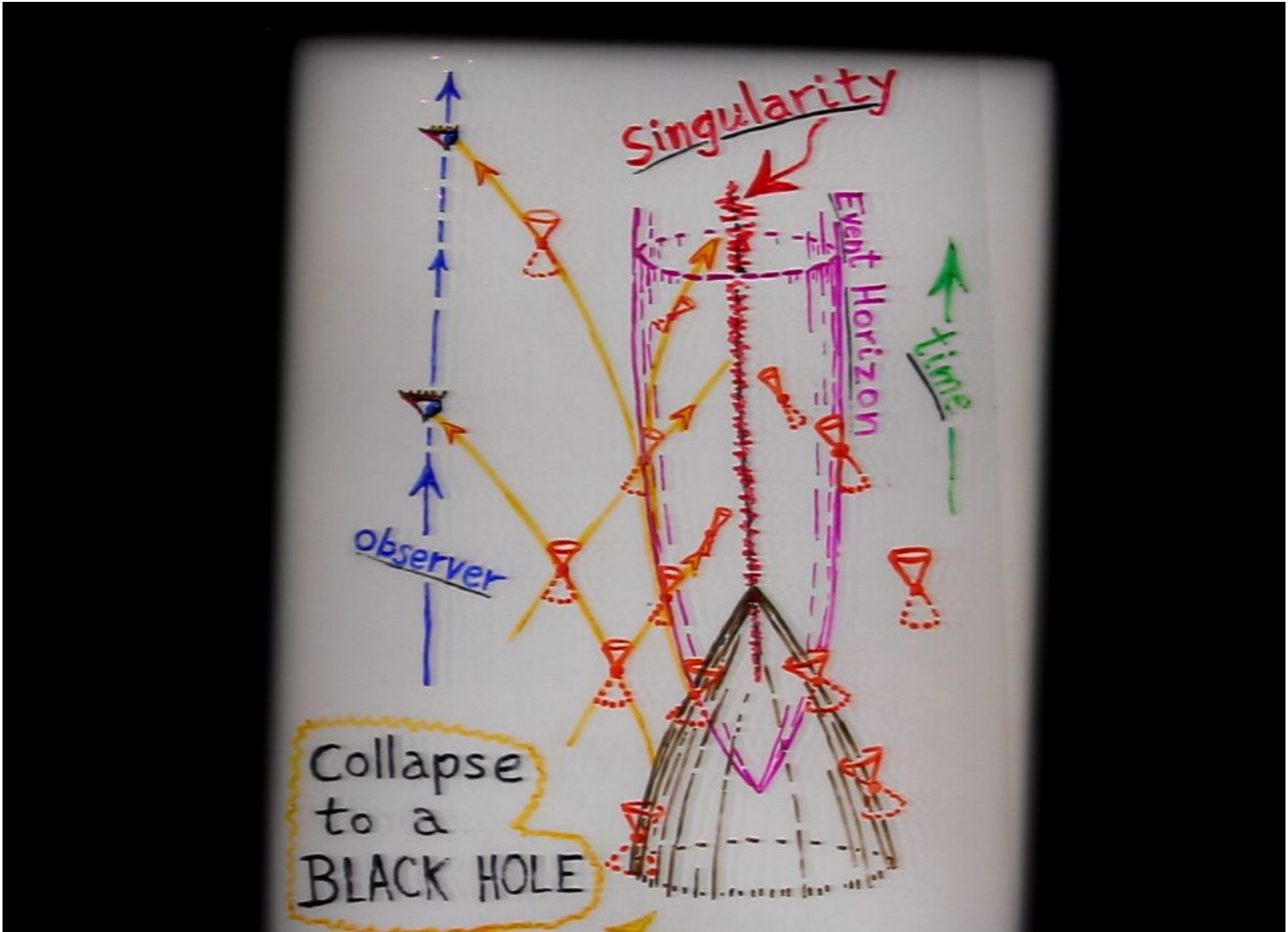
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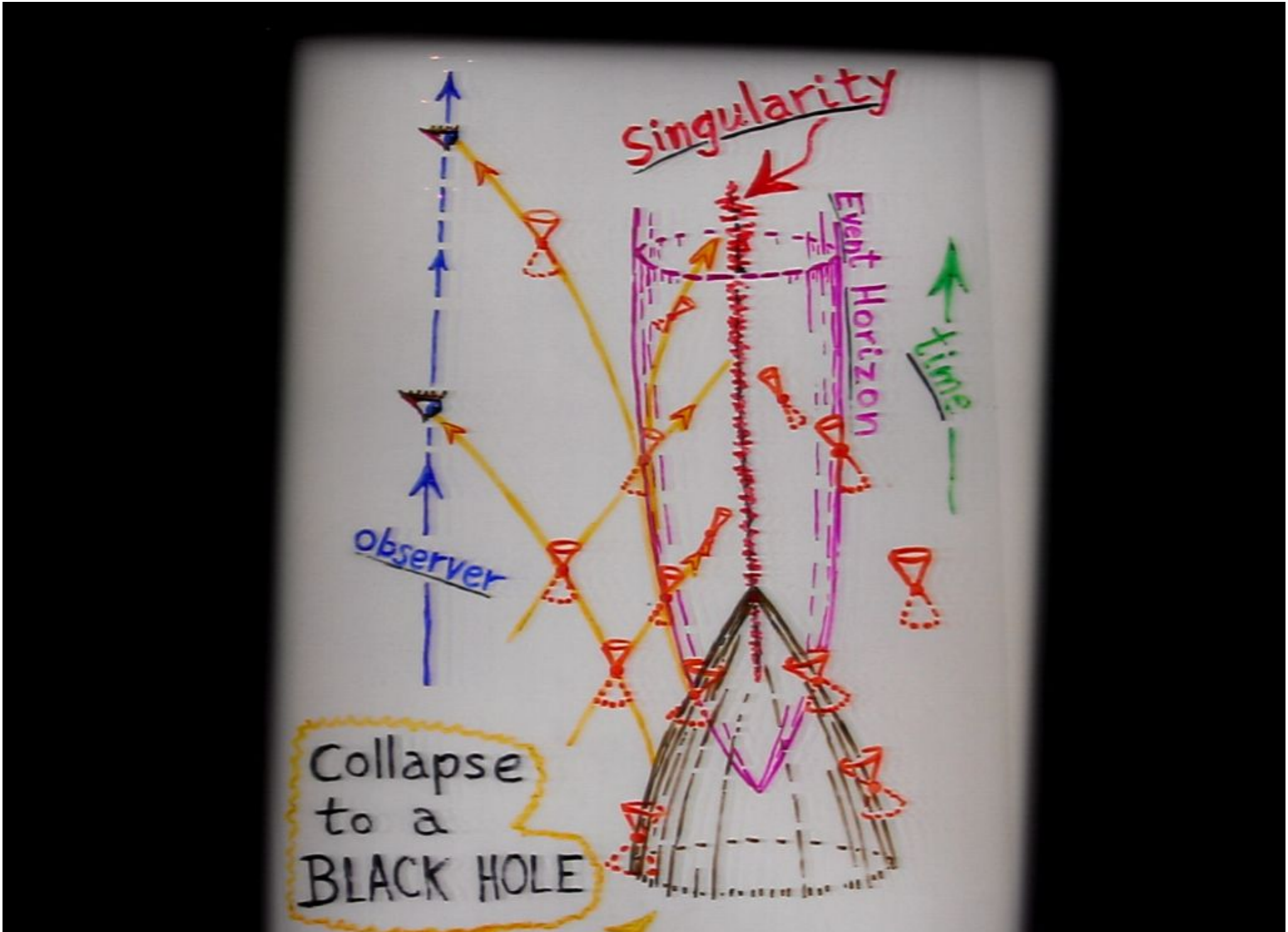
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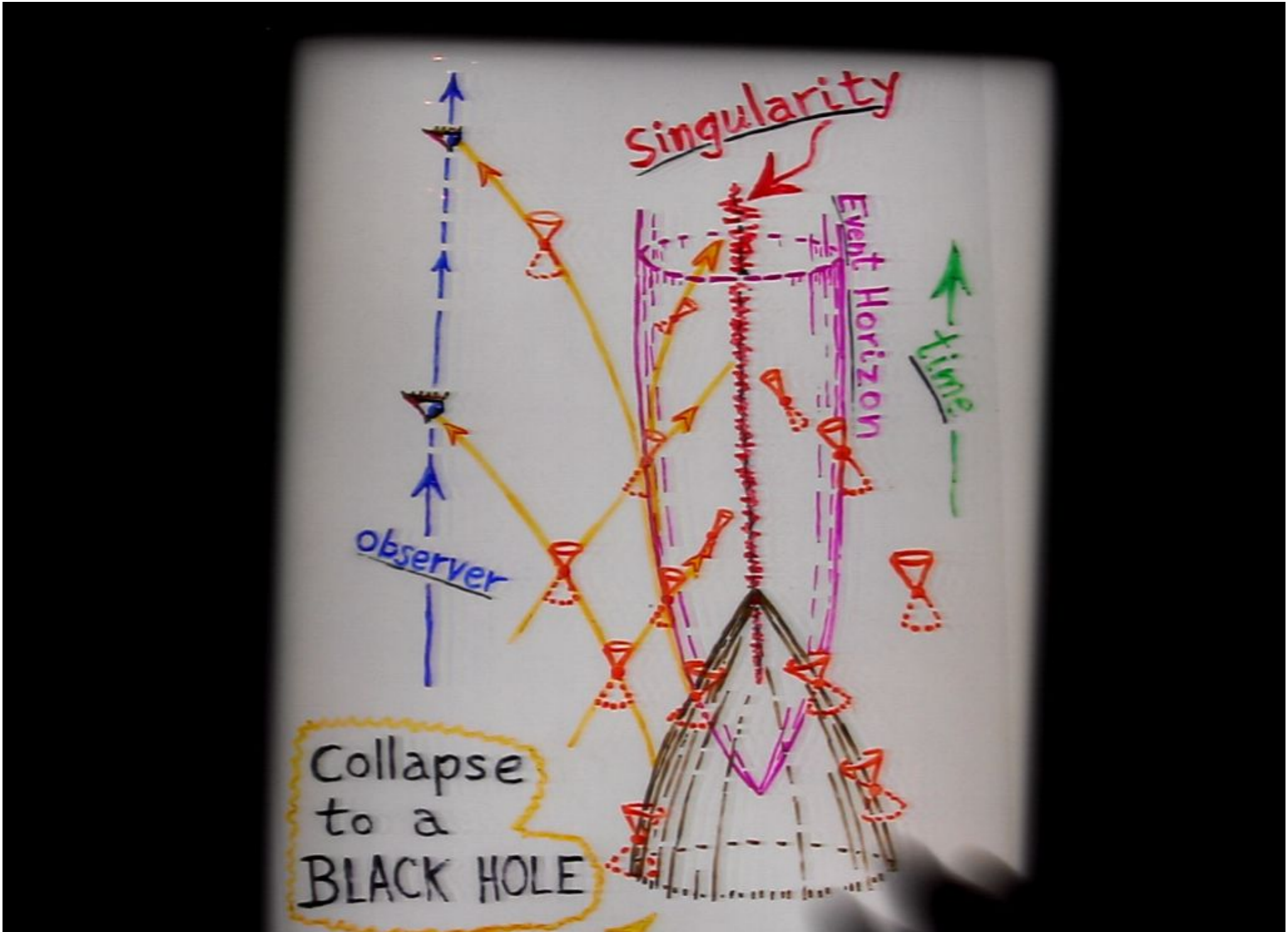
Singularity
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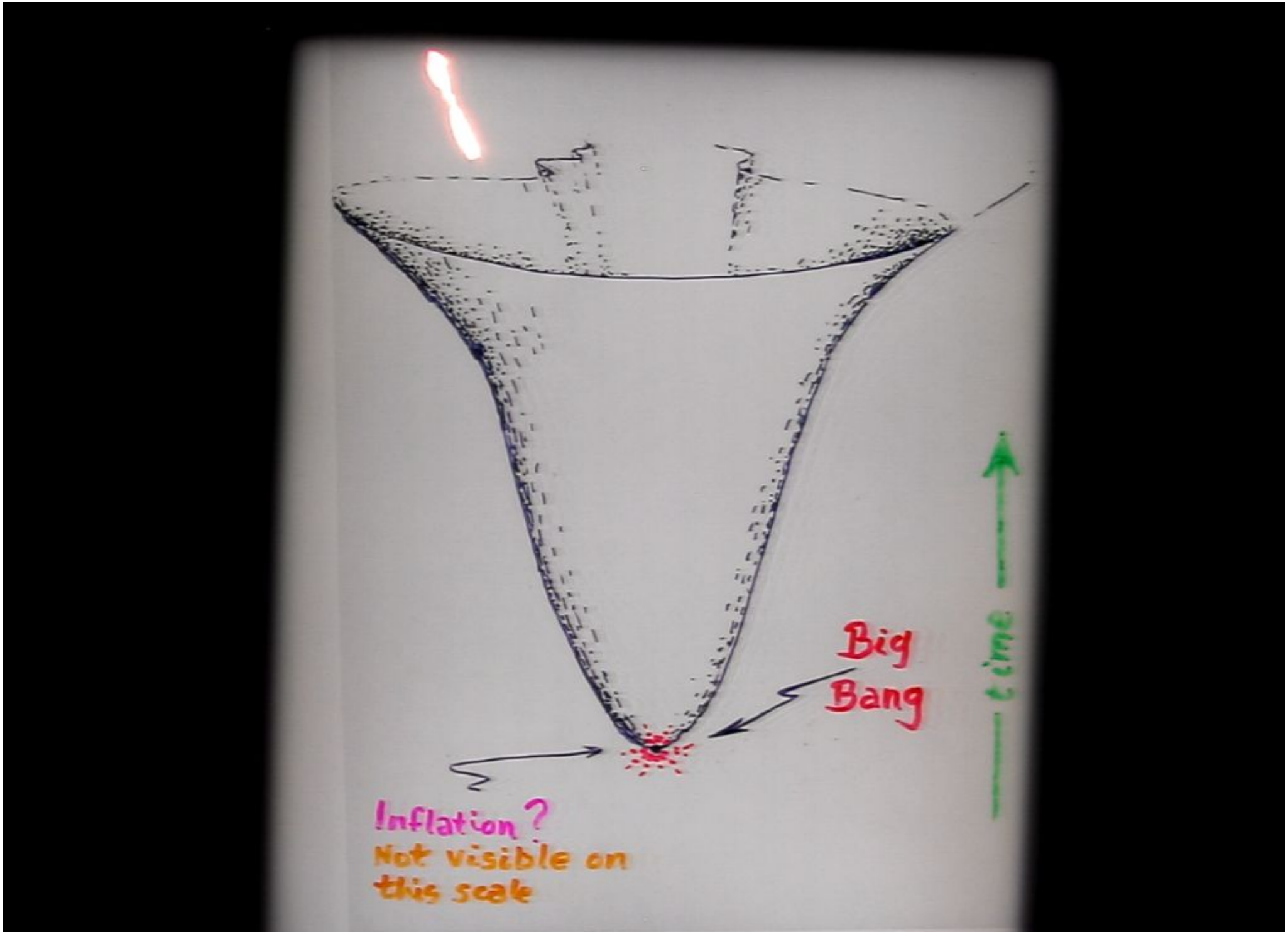
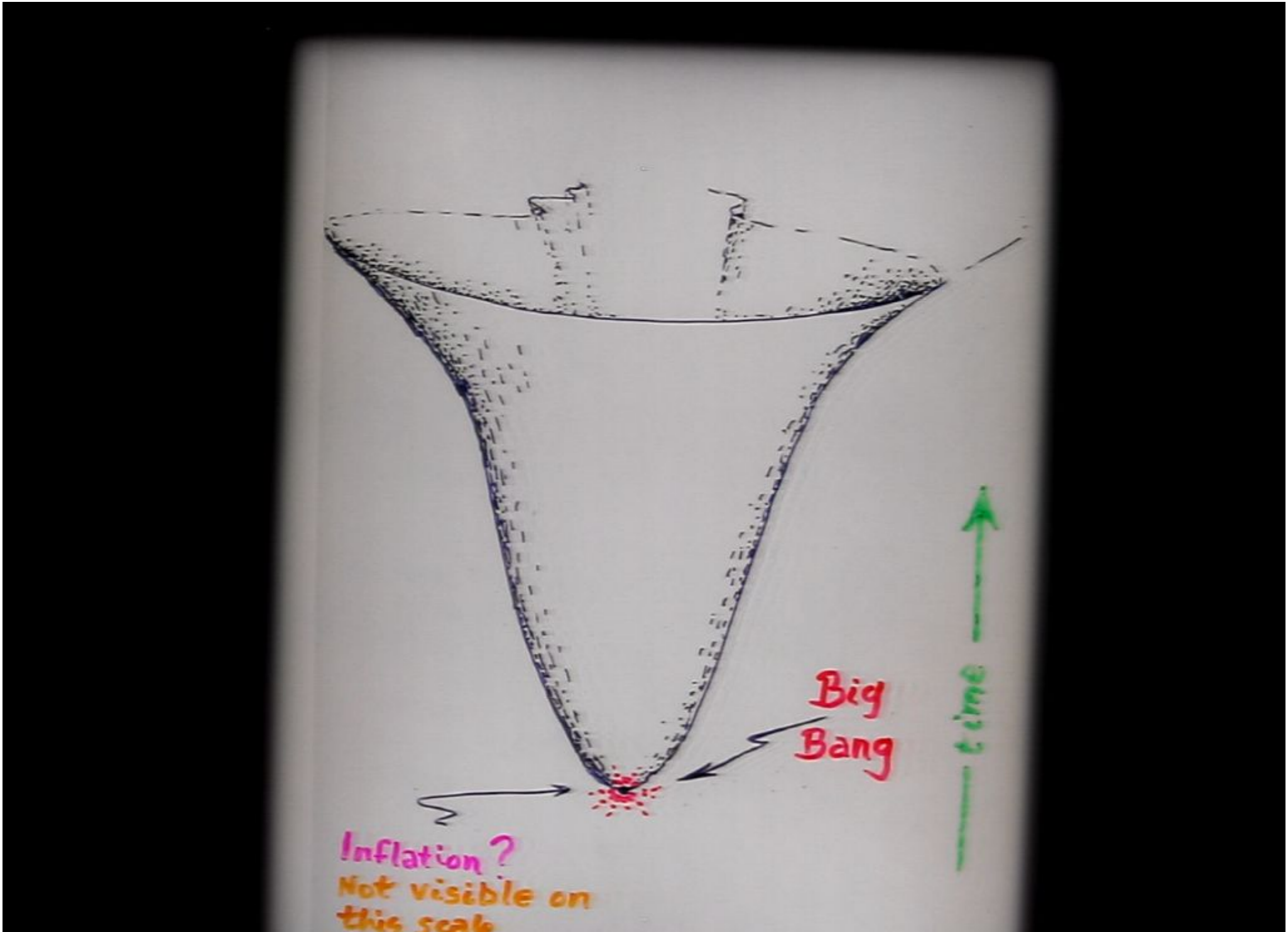

Big
Bang
time
Inflation?
Not visible on
this scale


Big
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time
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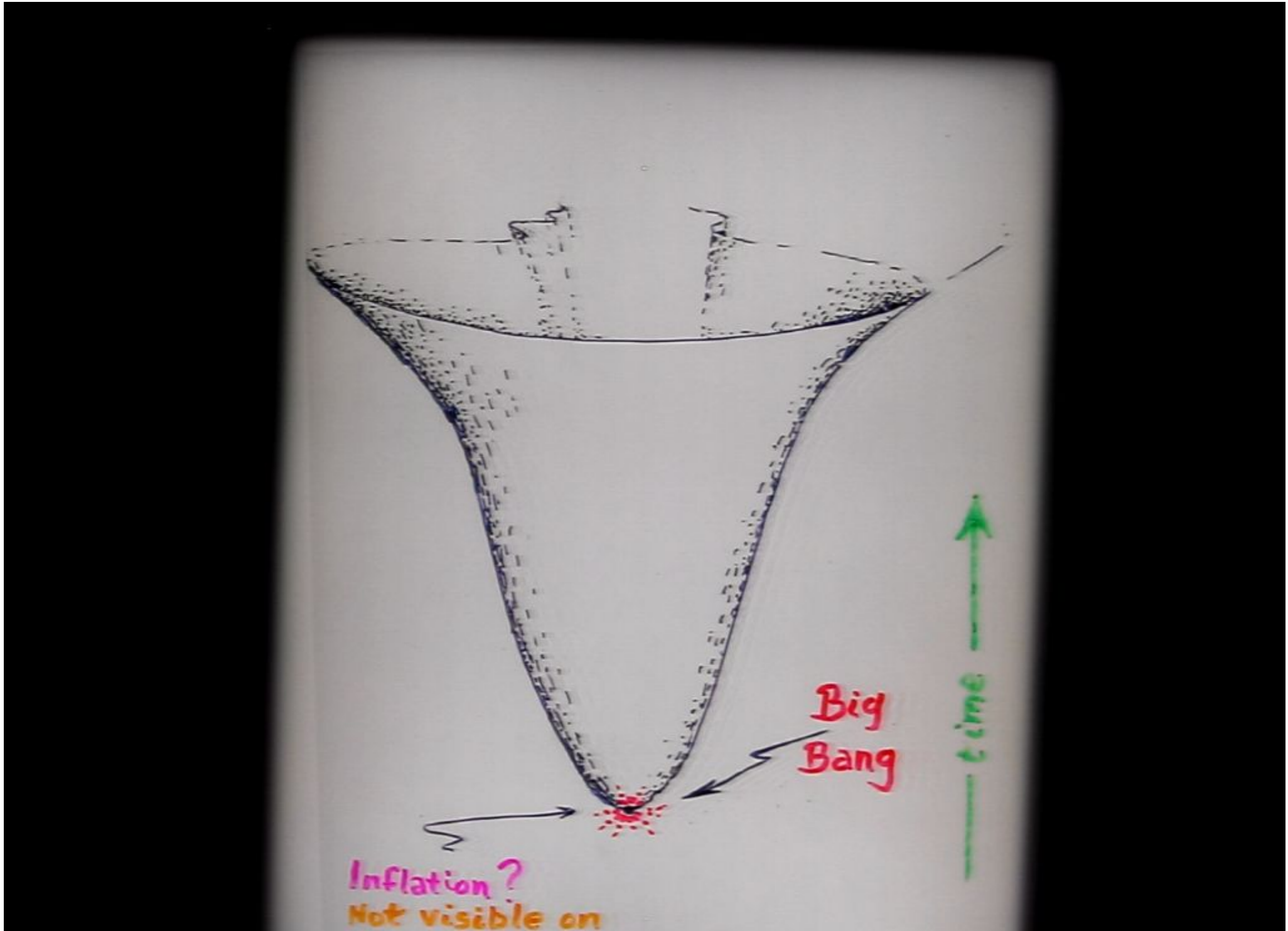
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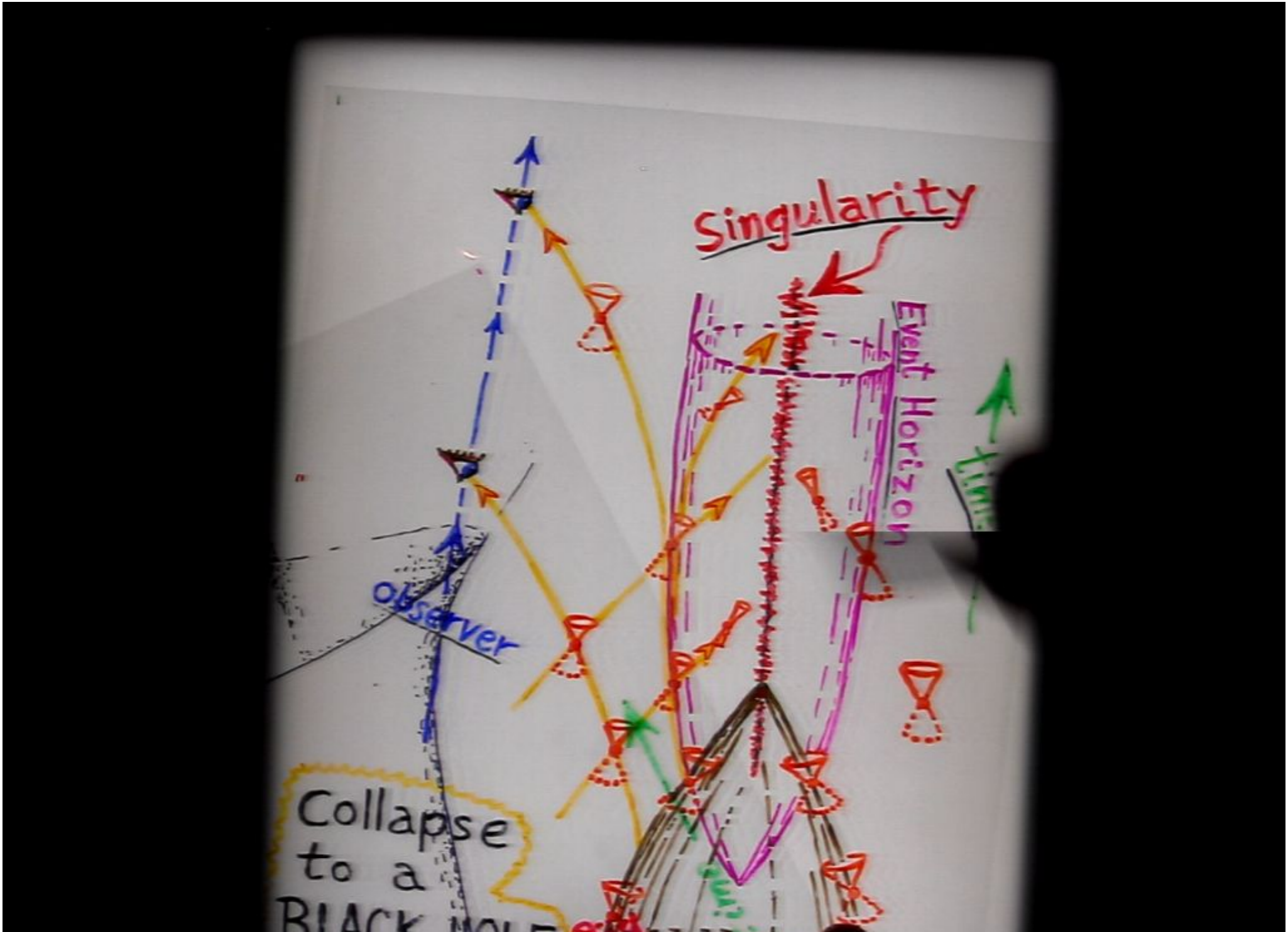
Singularity
Event Horizon
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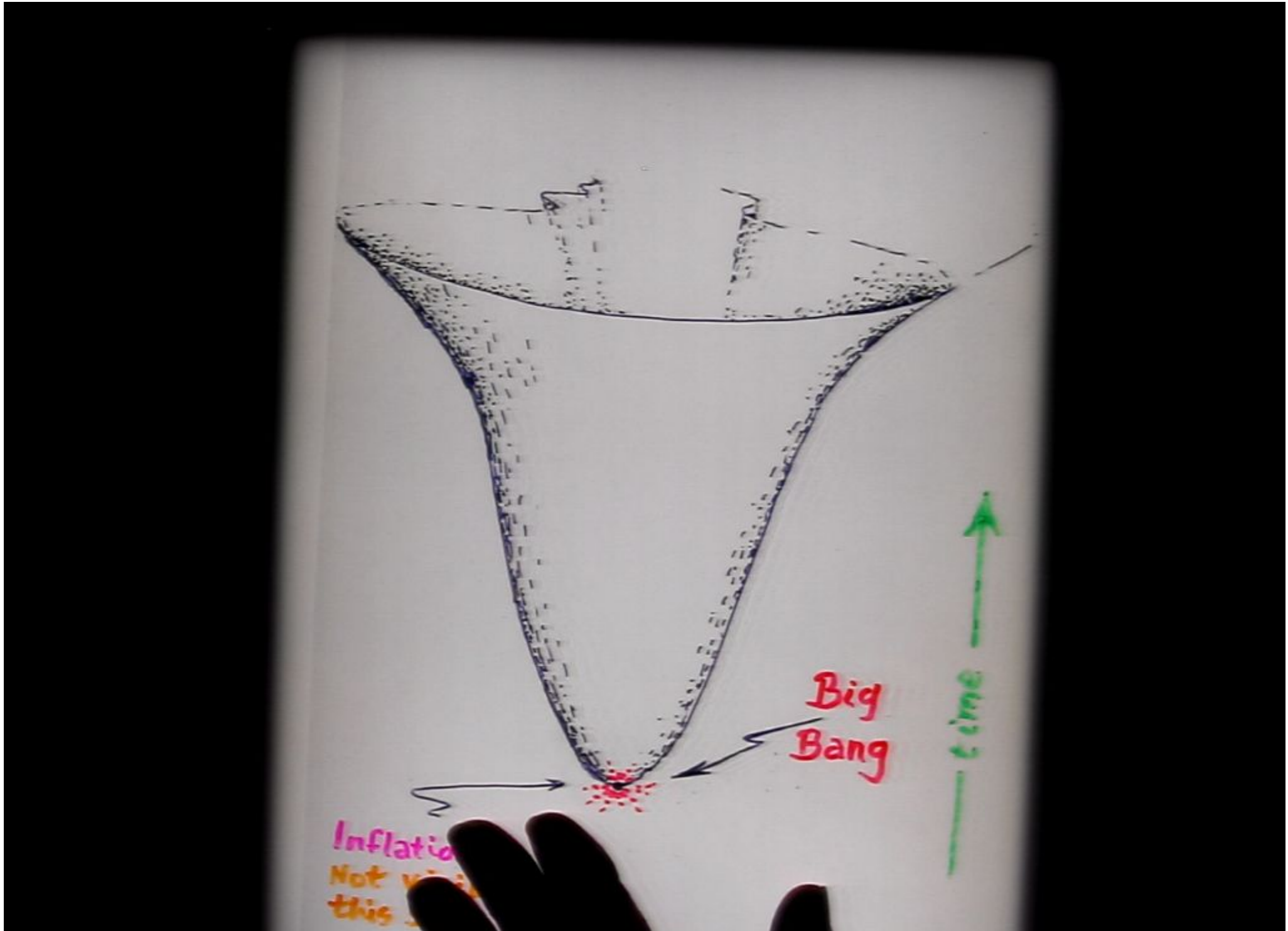
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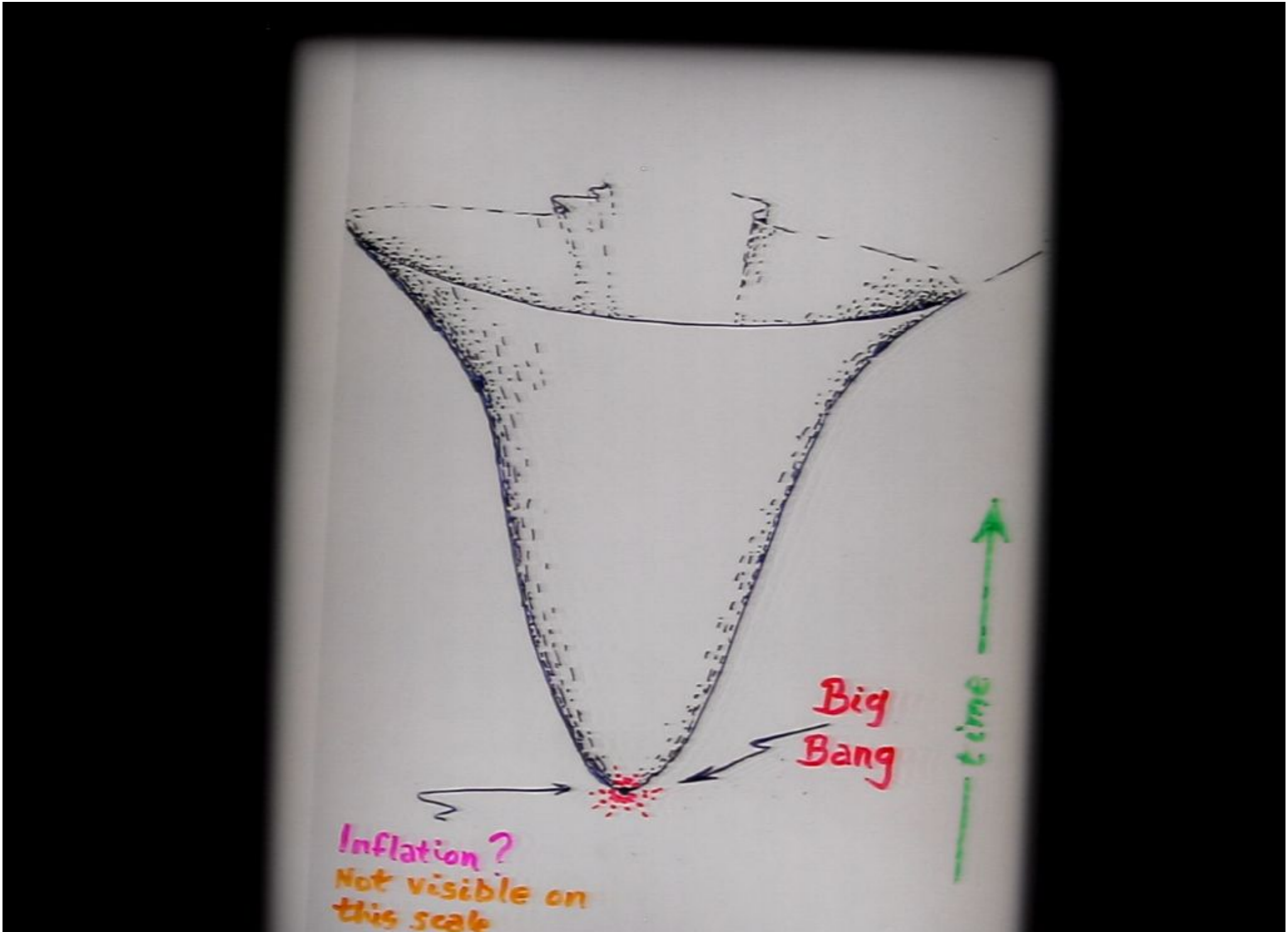
Big
Bang
time
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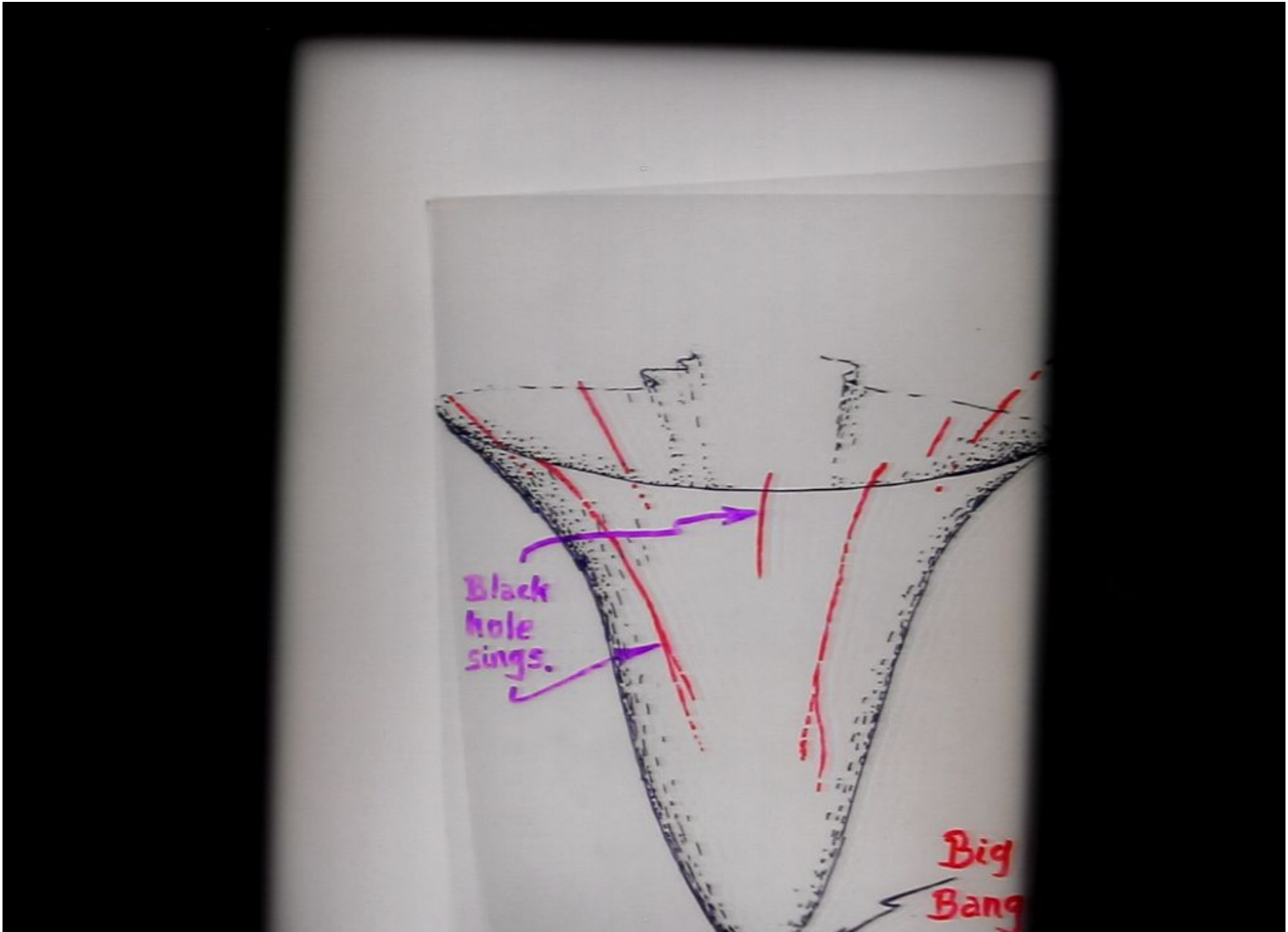
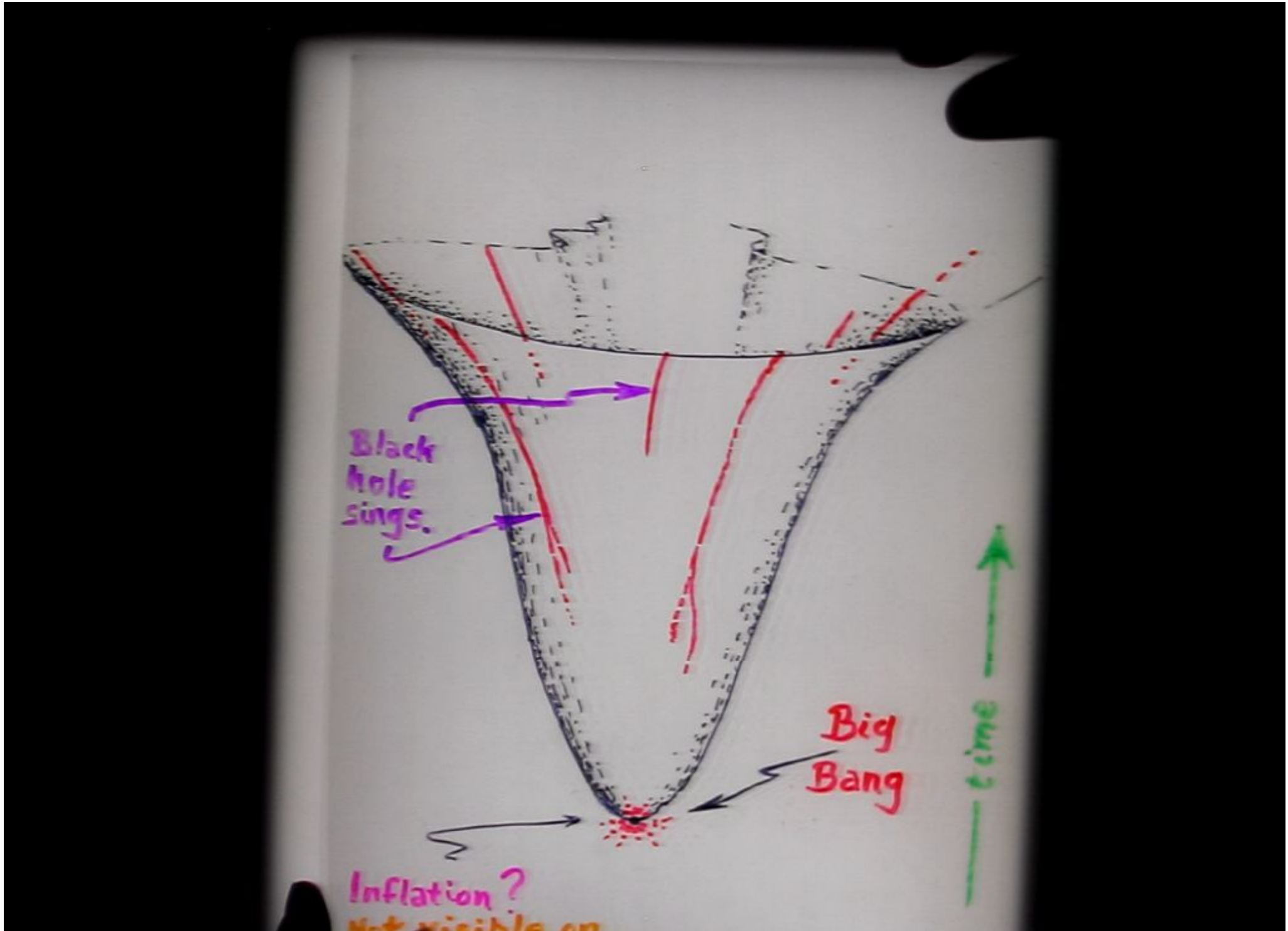
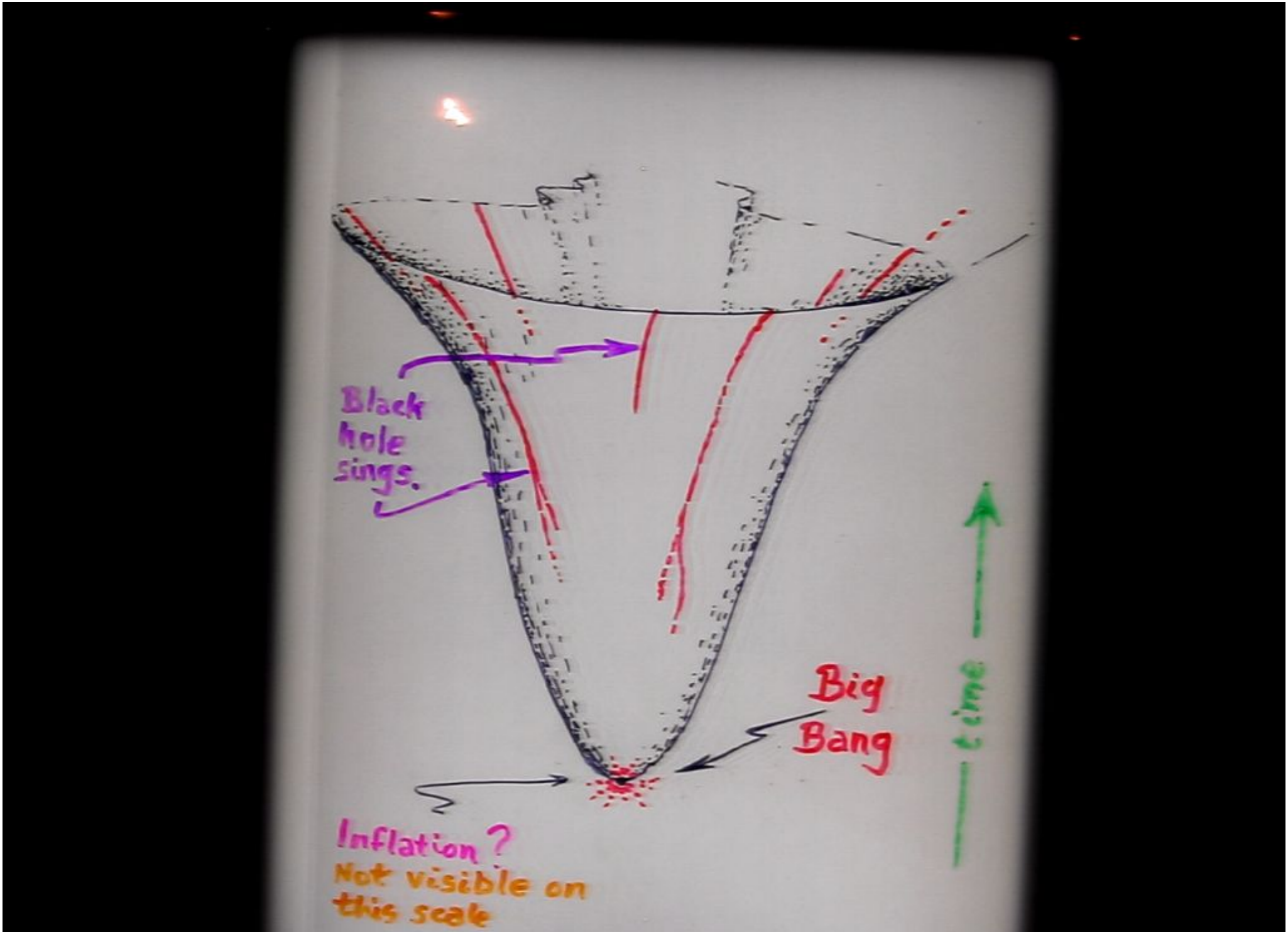
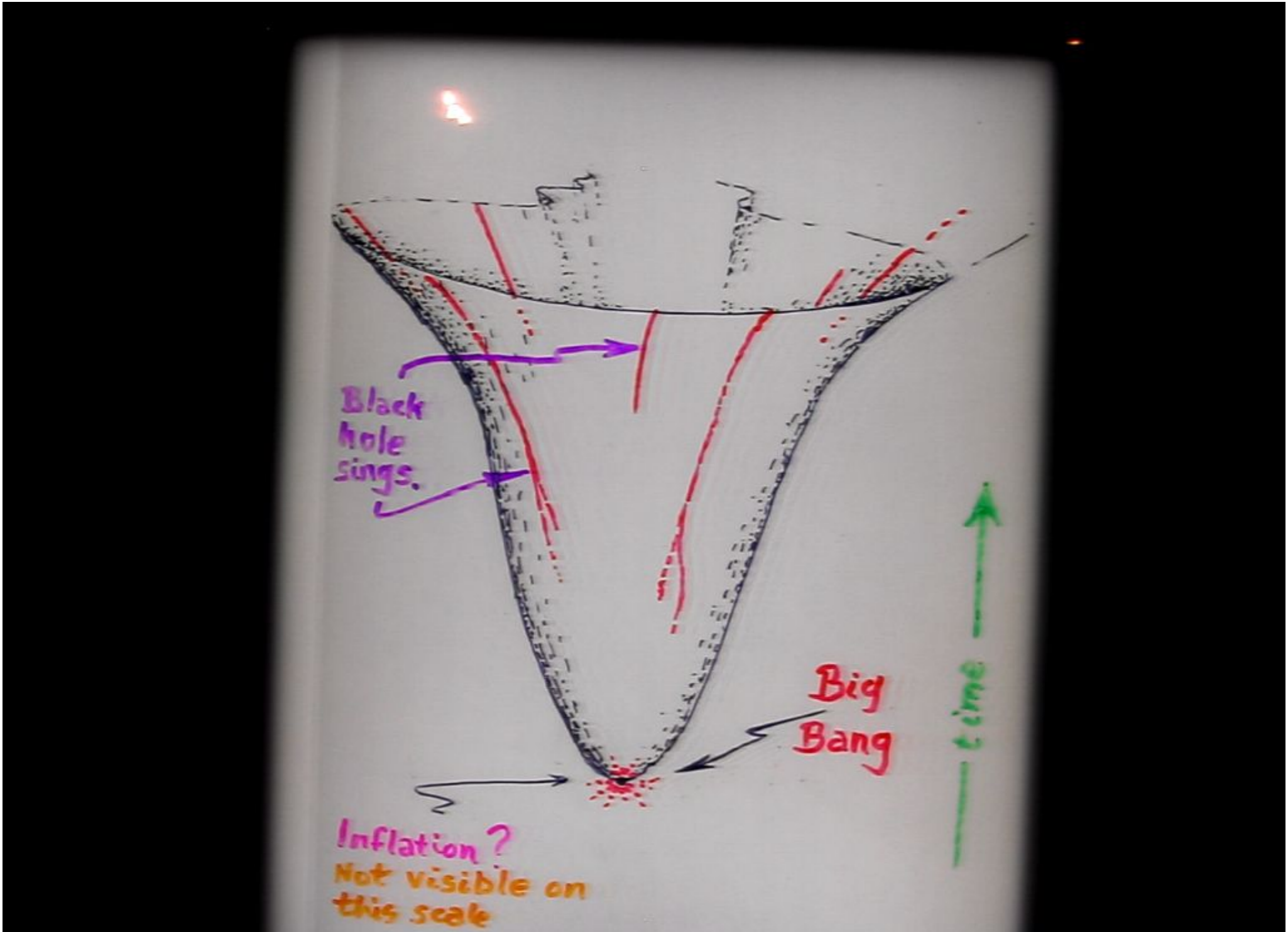

Black
hole
sings.
Big
Bang


Black hole sings.
Big Bang
time
Inflation ?


Black hole sings.
Big Bang
time
Inflation ?
Not visible on this scale


Black hole sings.
Big Bang
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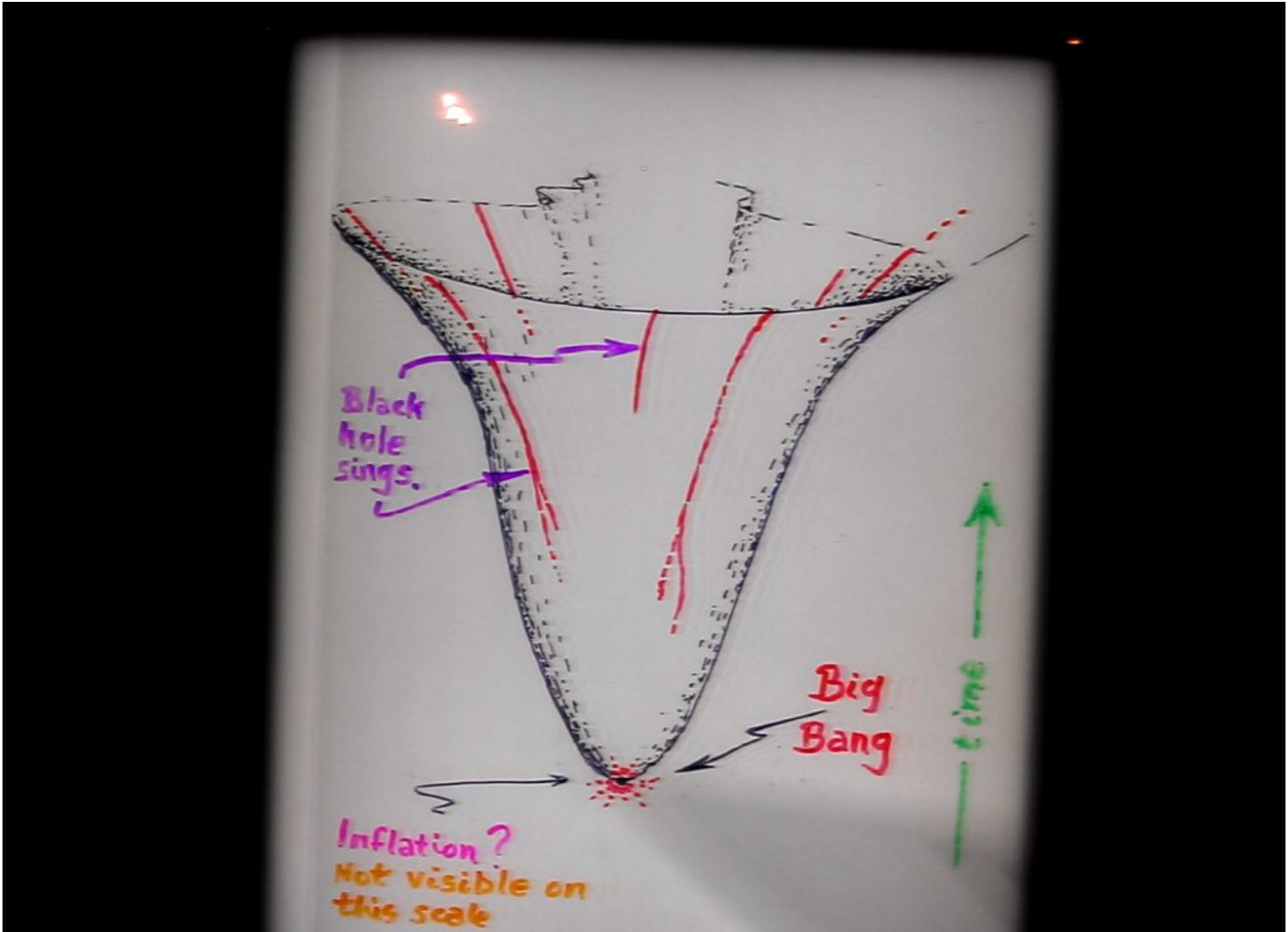
Black hole sings.
Big Bang
time
Inflation ?
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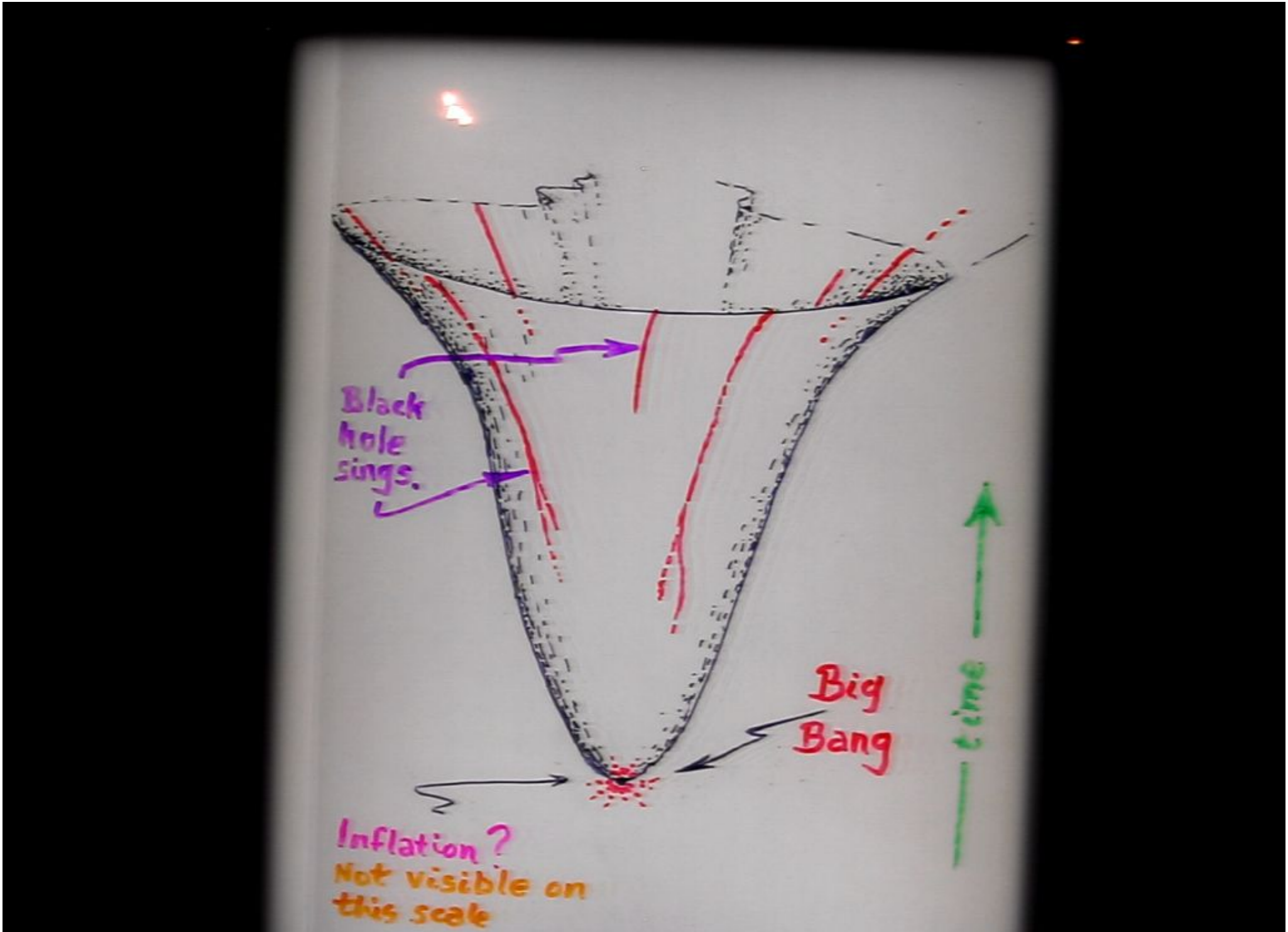
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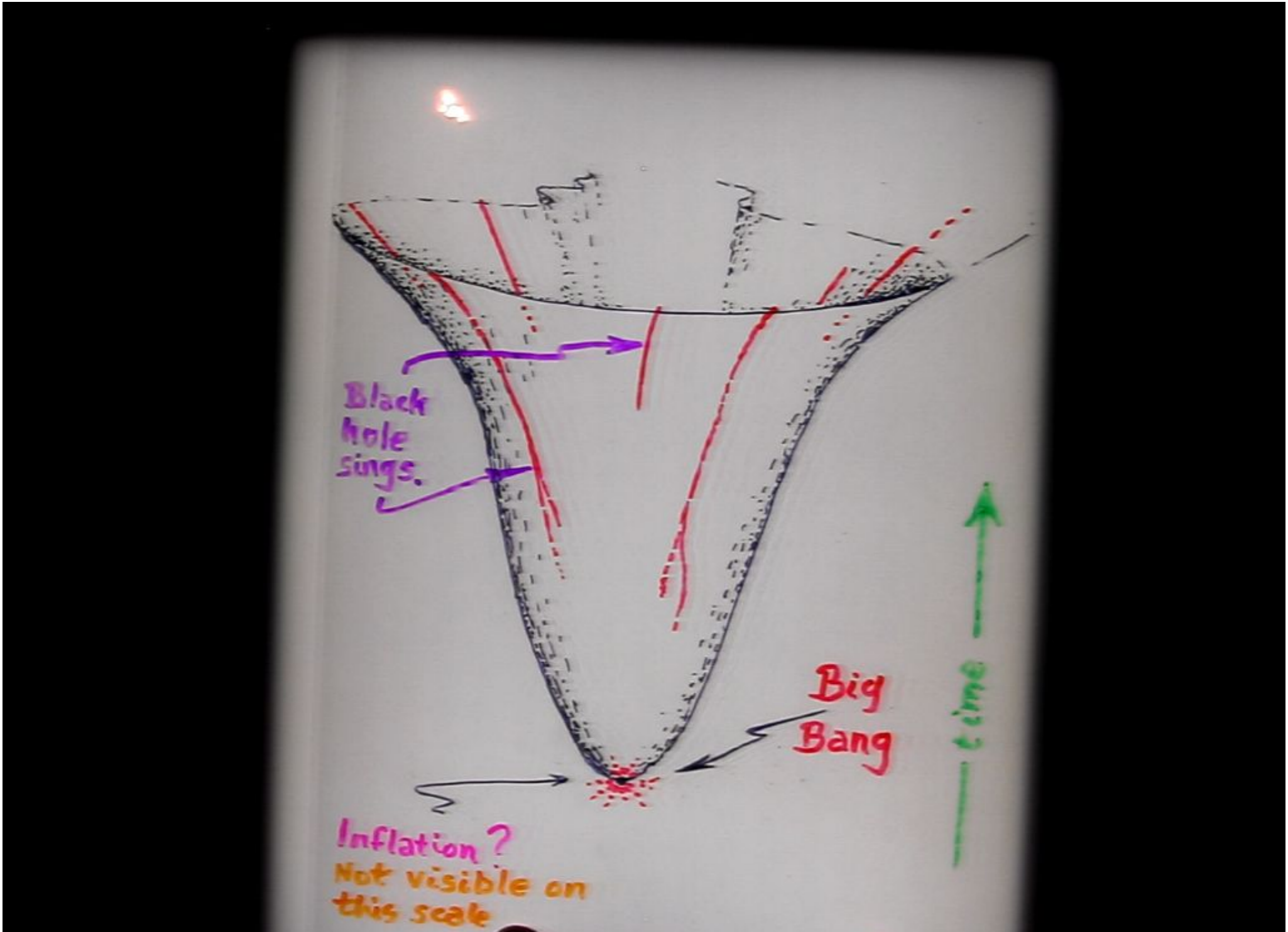
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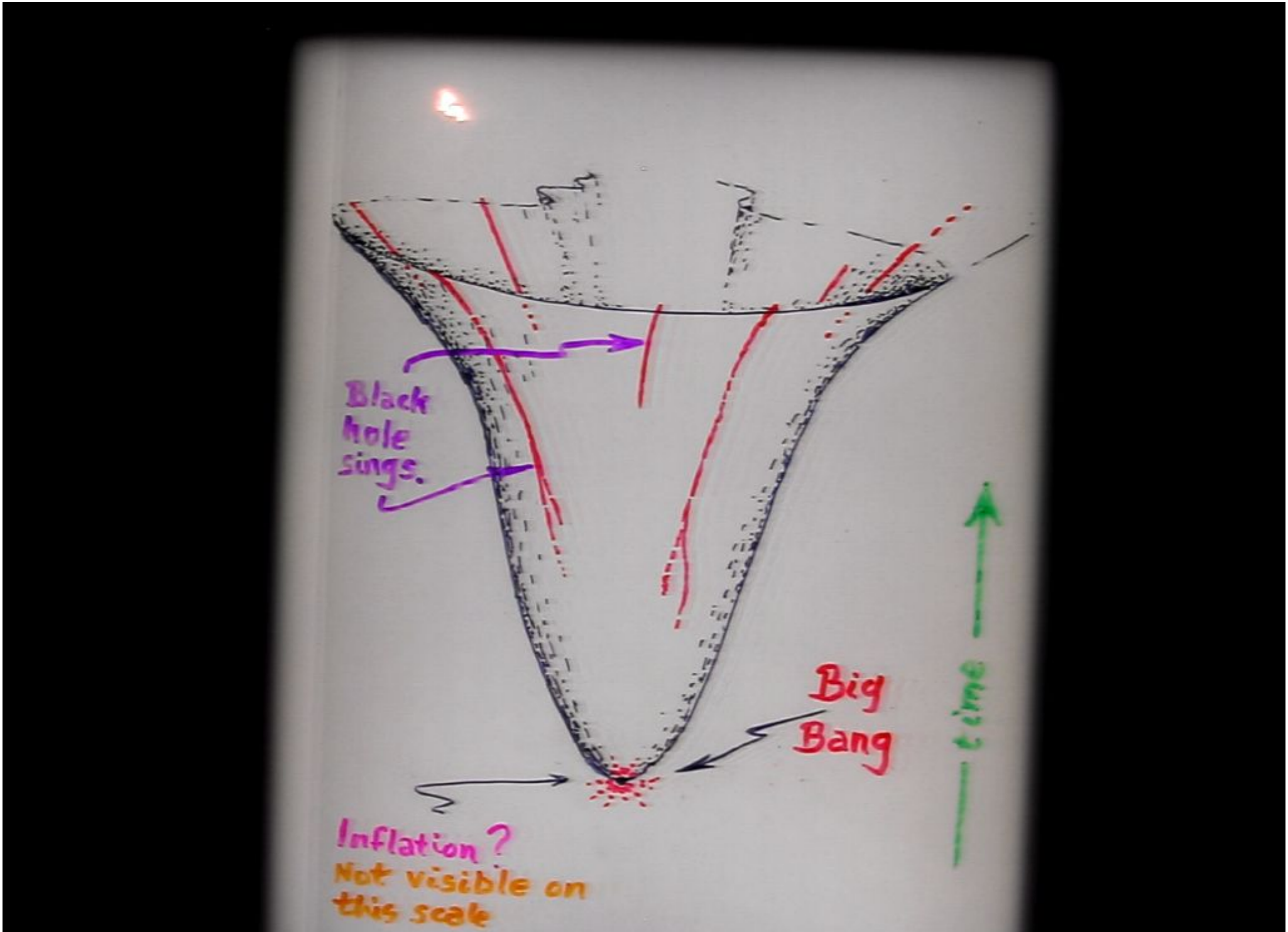
Inflation ?
Not visible on this scale


Black hole sings.
Big Bang
time
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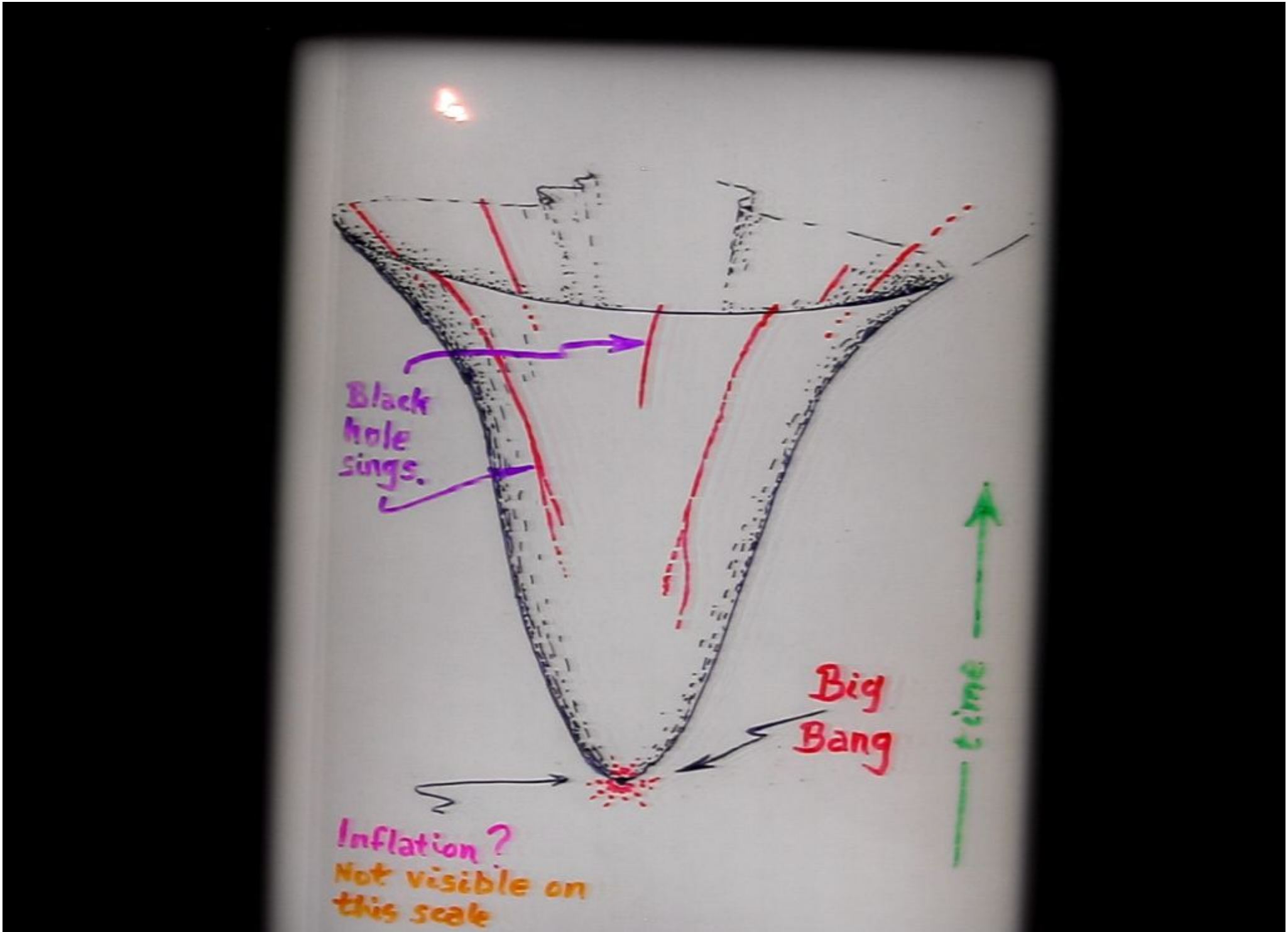
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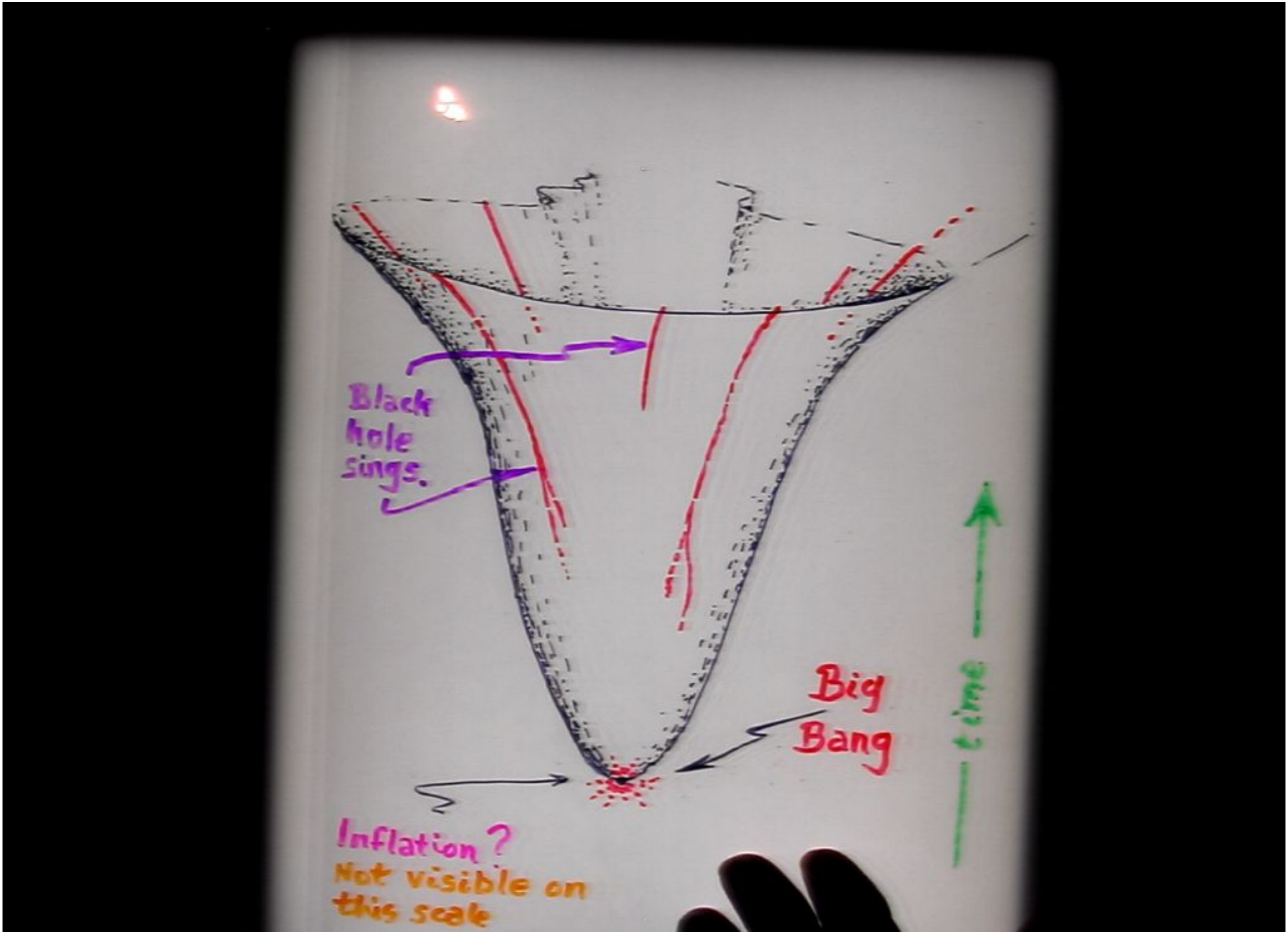
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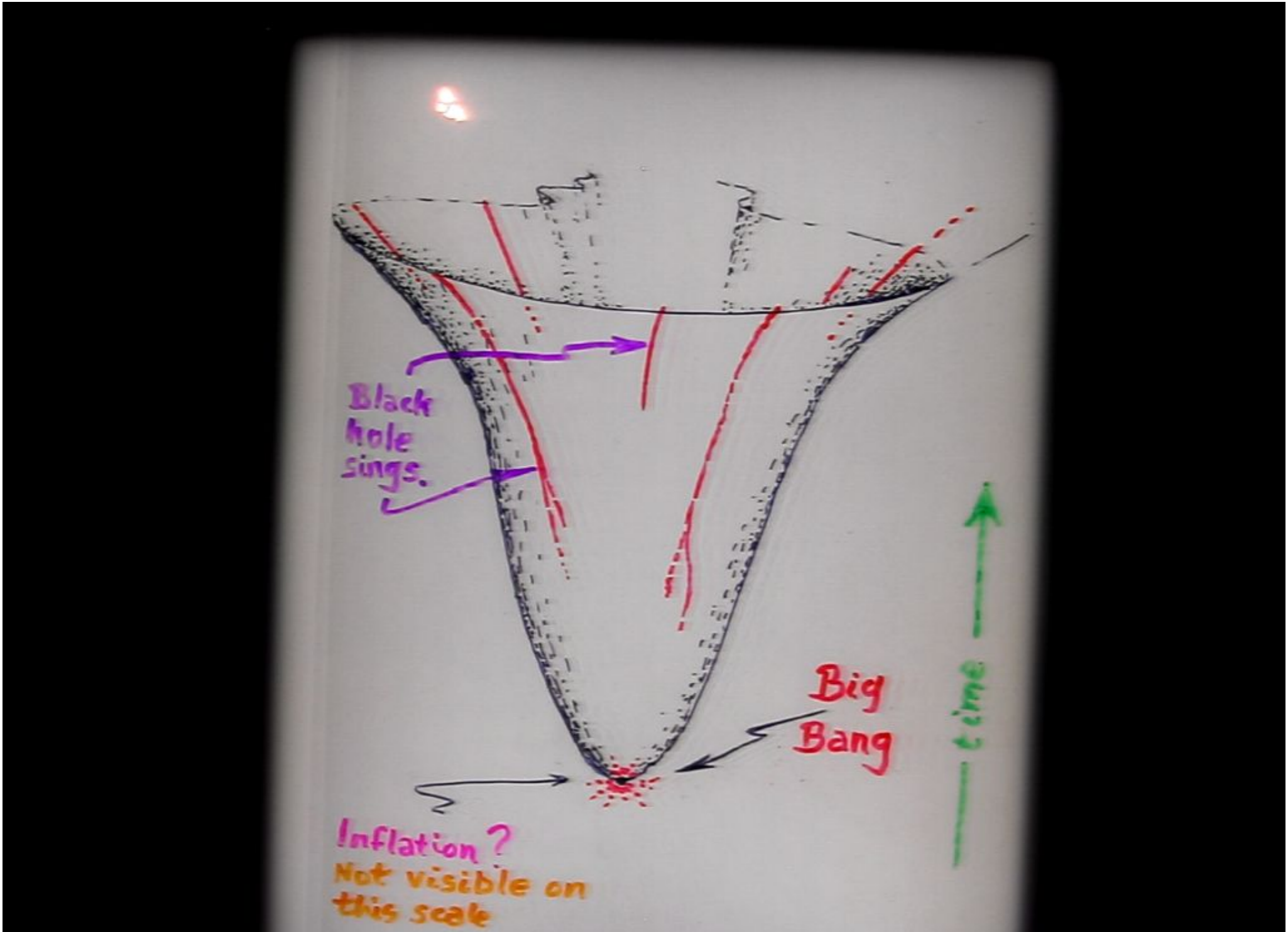
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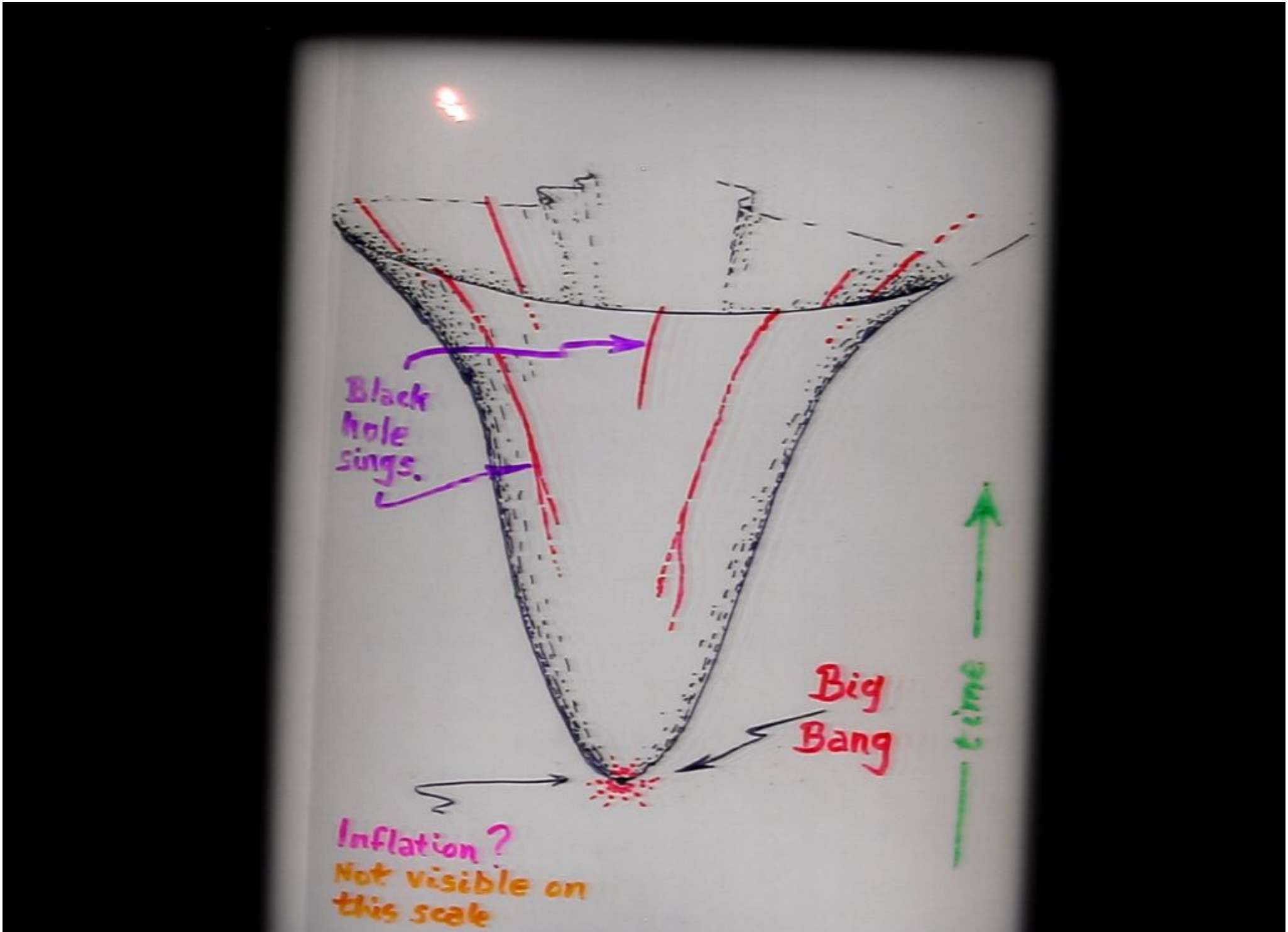
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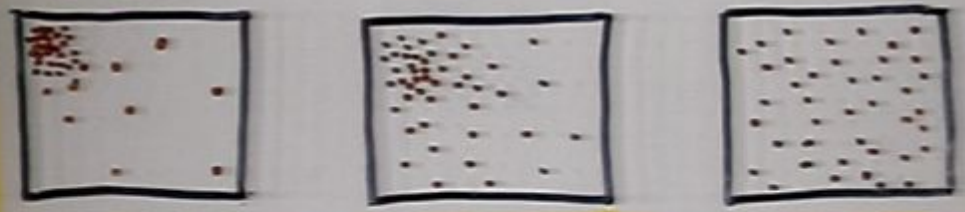
2nd Law of Thermodynamics

Entropy increases with time

= "disorder" (roughly speaking)

Gas in a box



time increases →
entropy increases →

Gravitating bodies



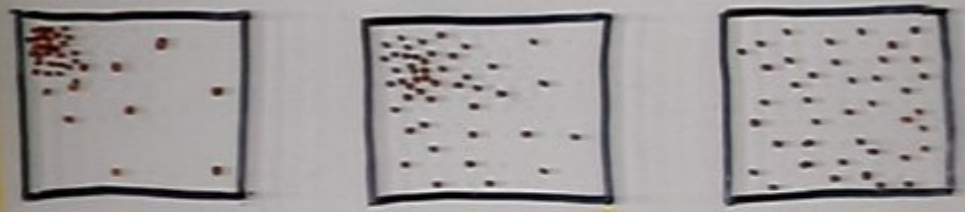
Maximum entropy:
BLACK HOLE

2nd Law of Thermodynamics

Entropy increases with time

↑ = "disorder" (roughly speaking)

Gas in a box



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Gravitating bodies



Maximum entropy:
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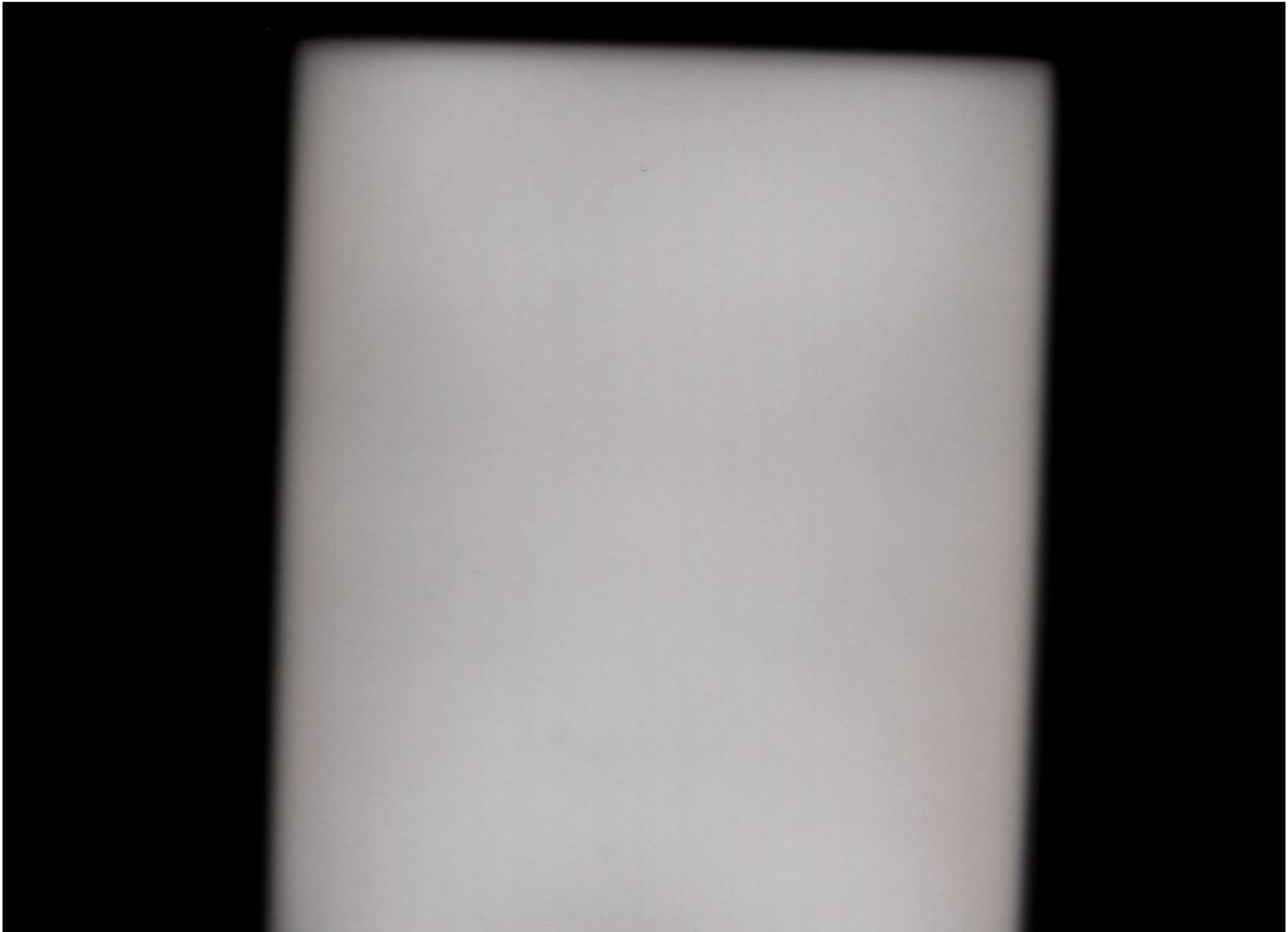

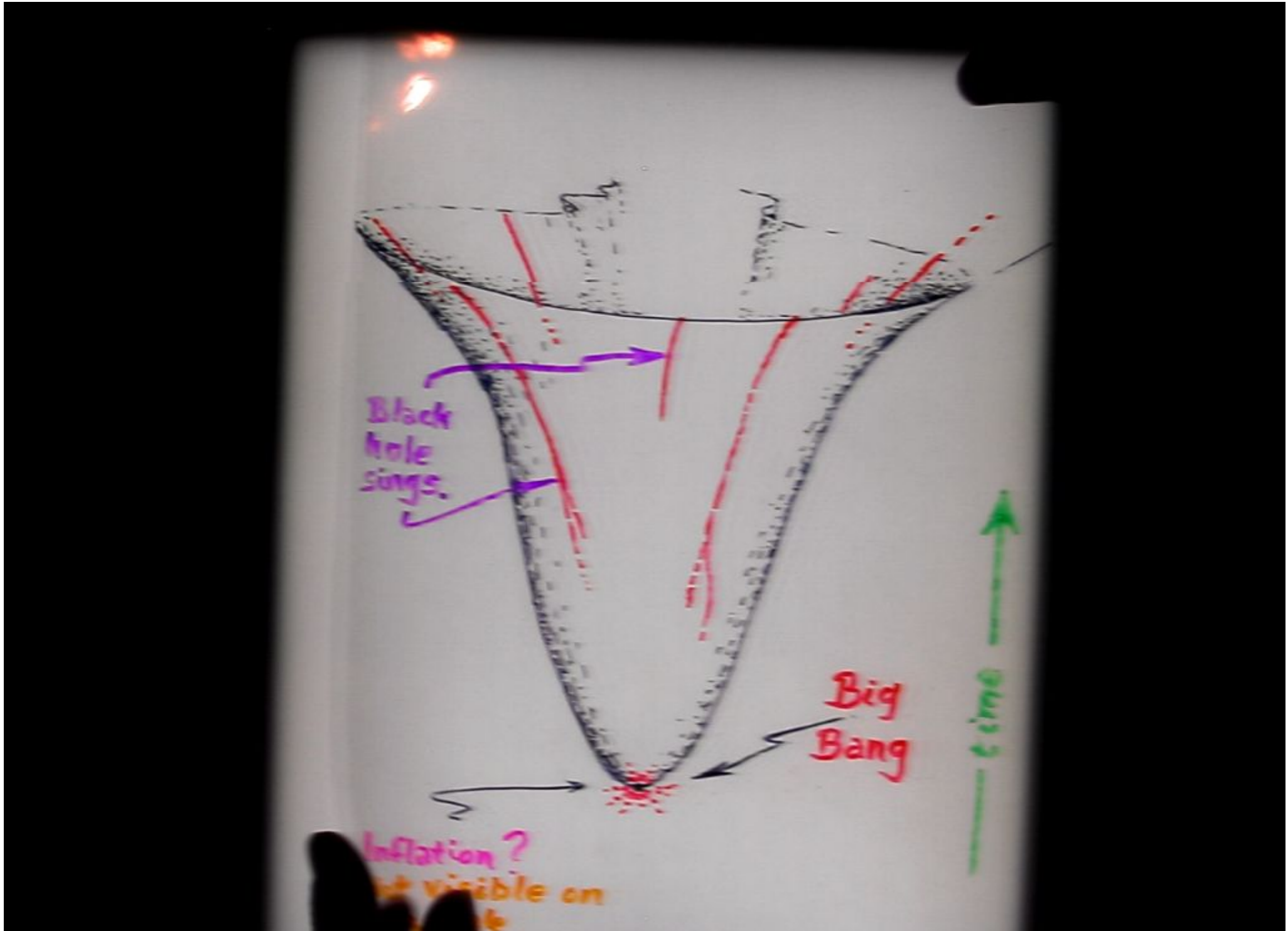
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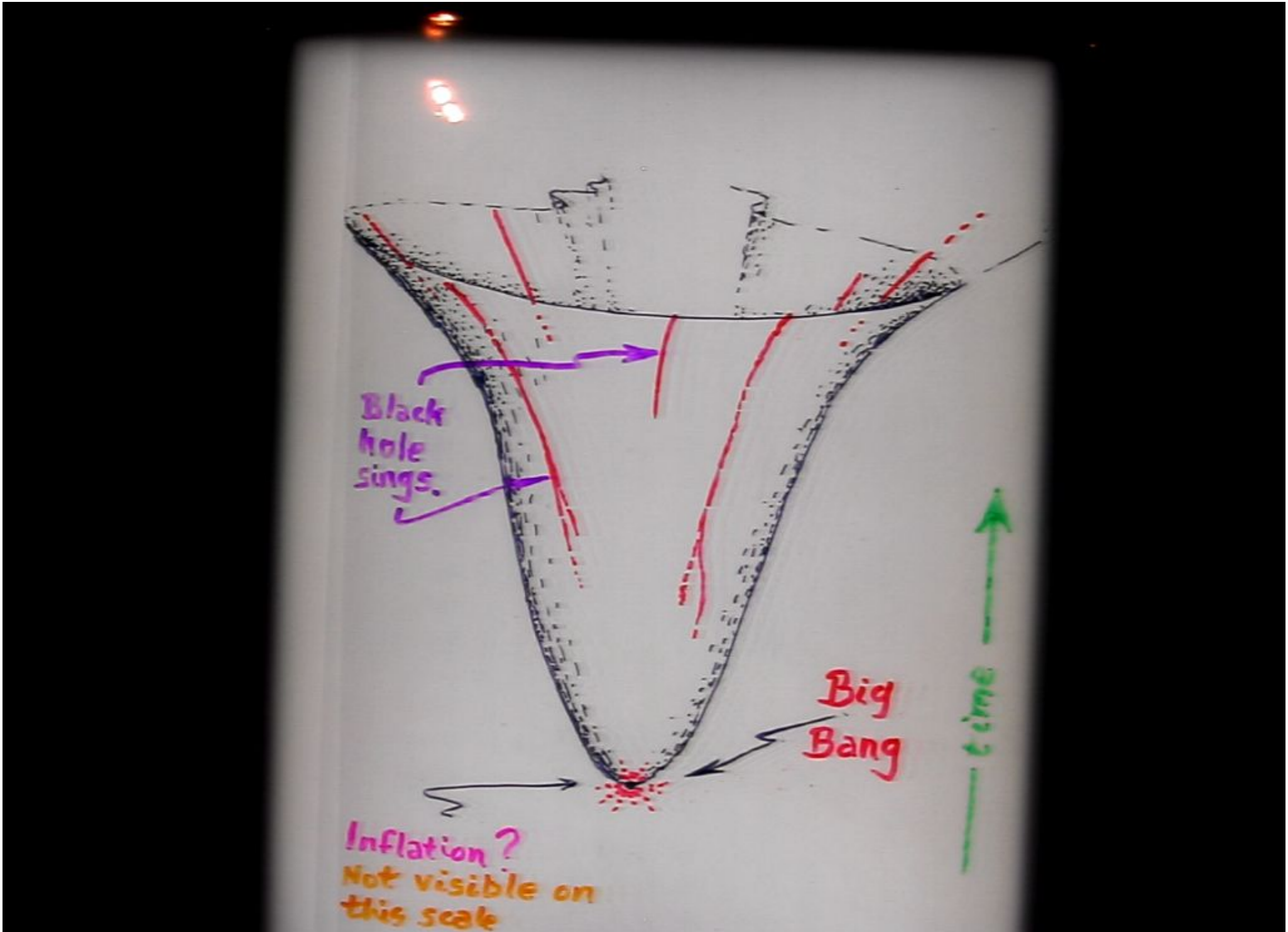
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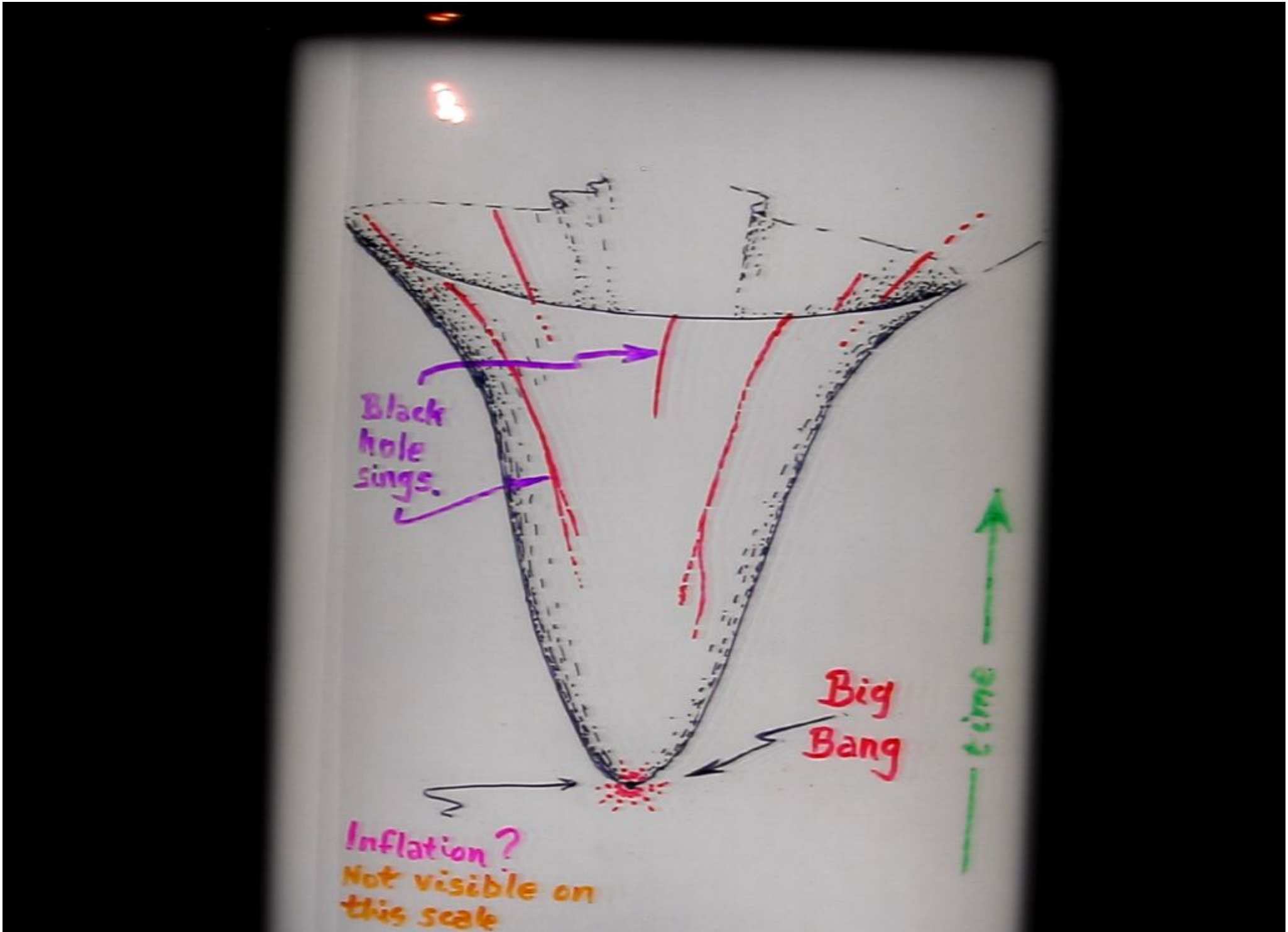
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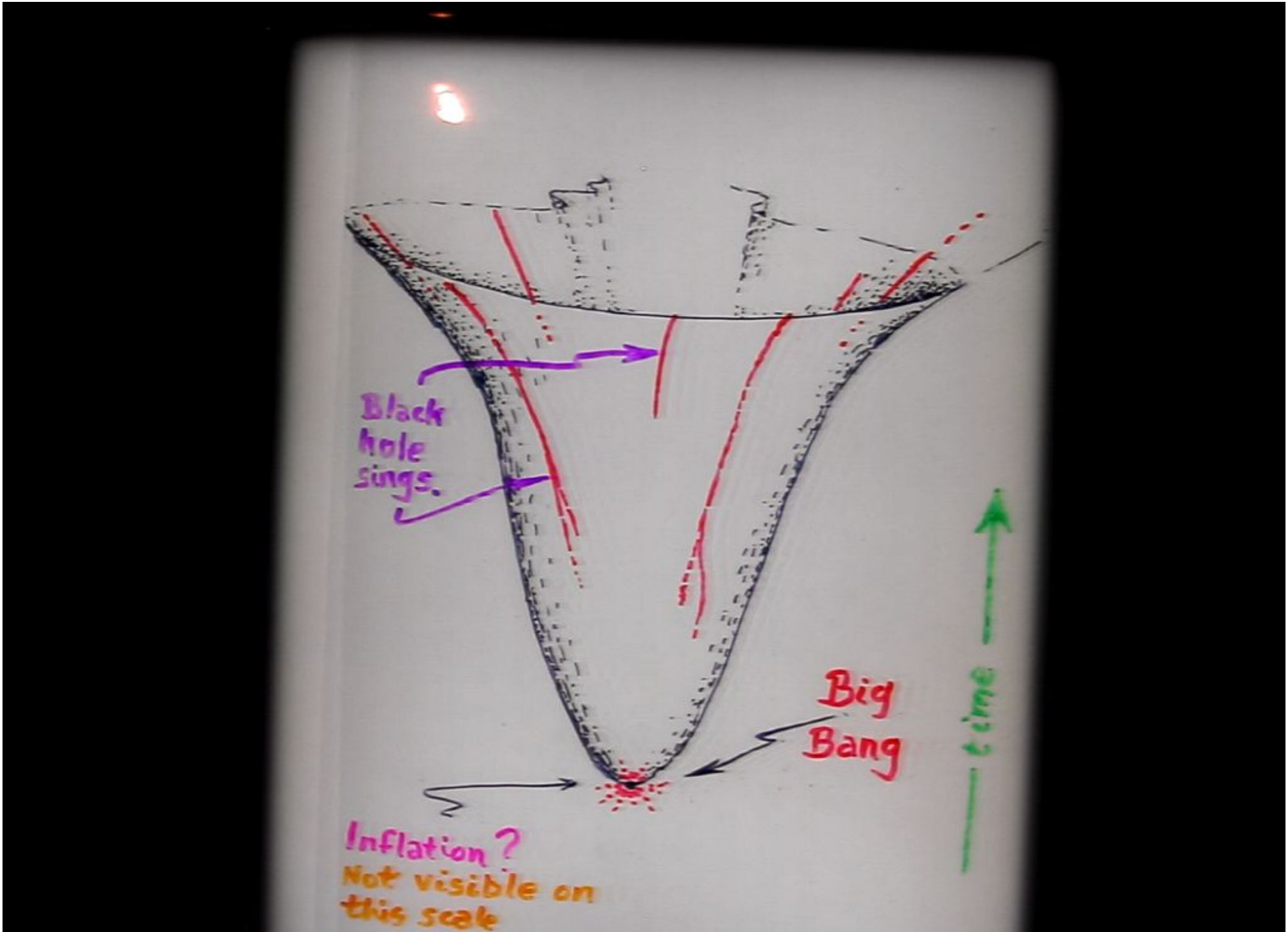
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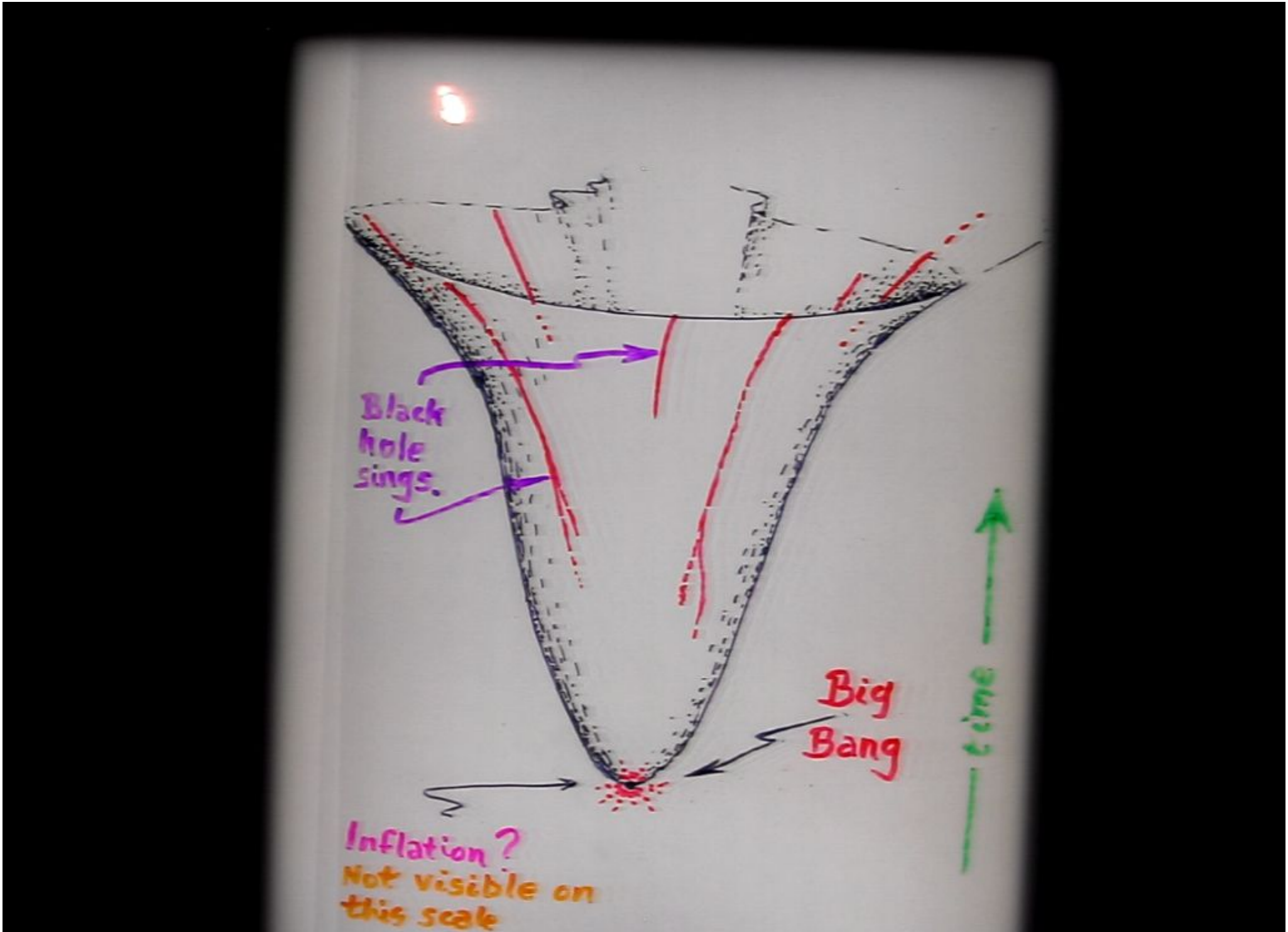
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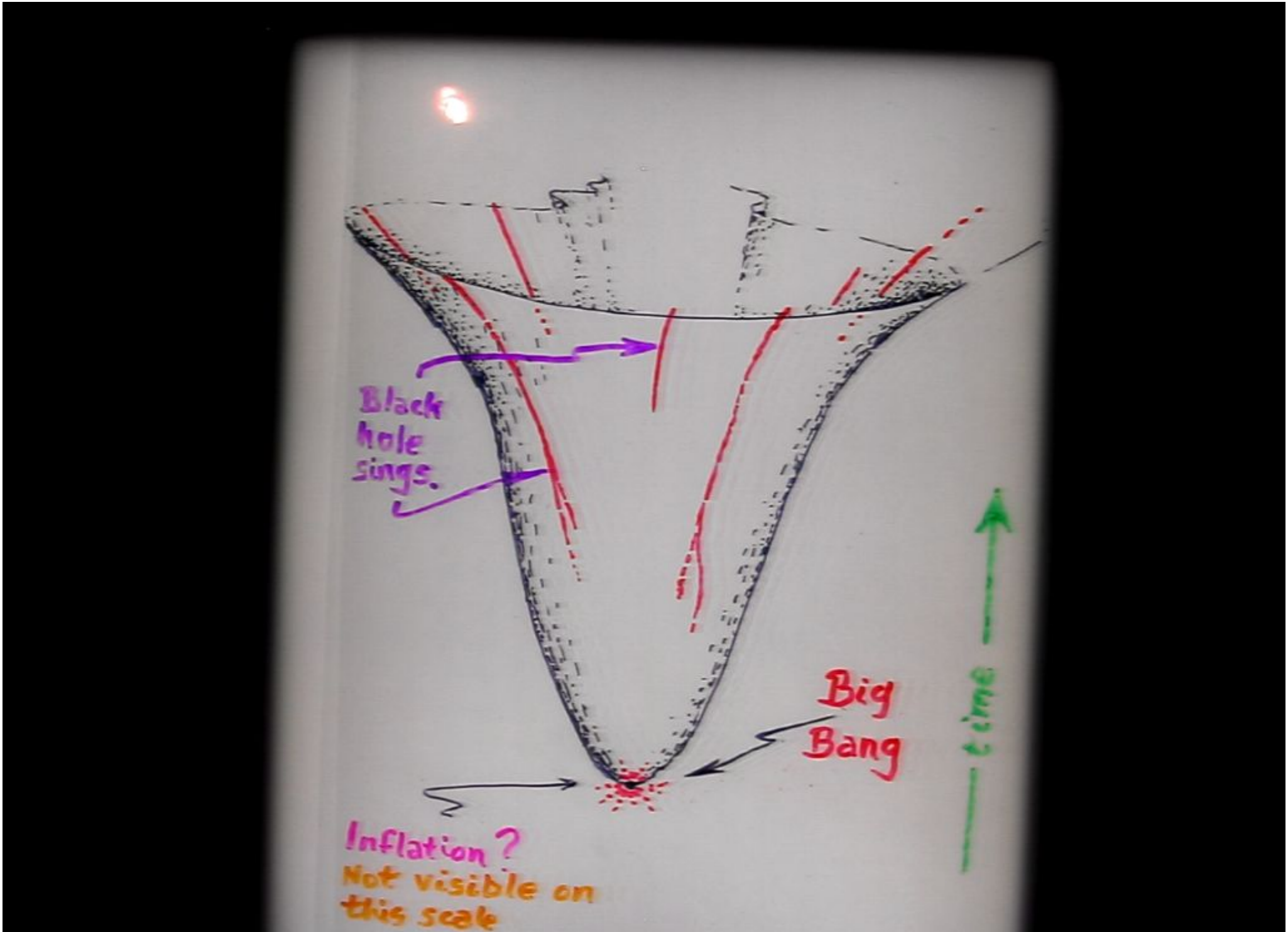
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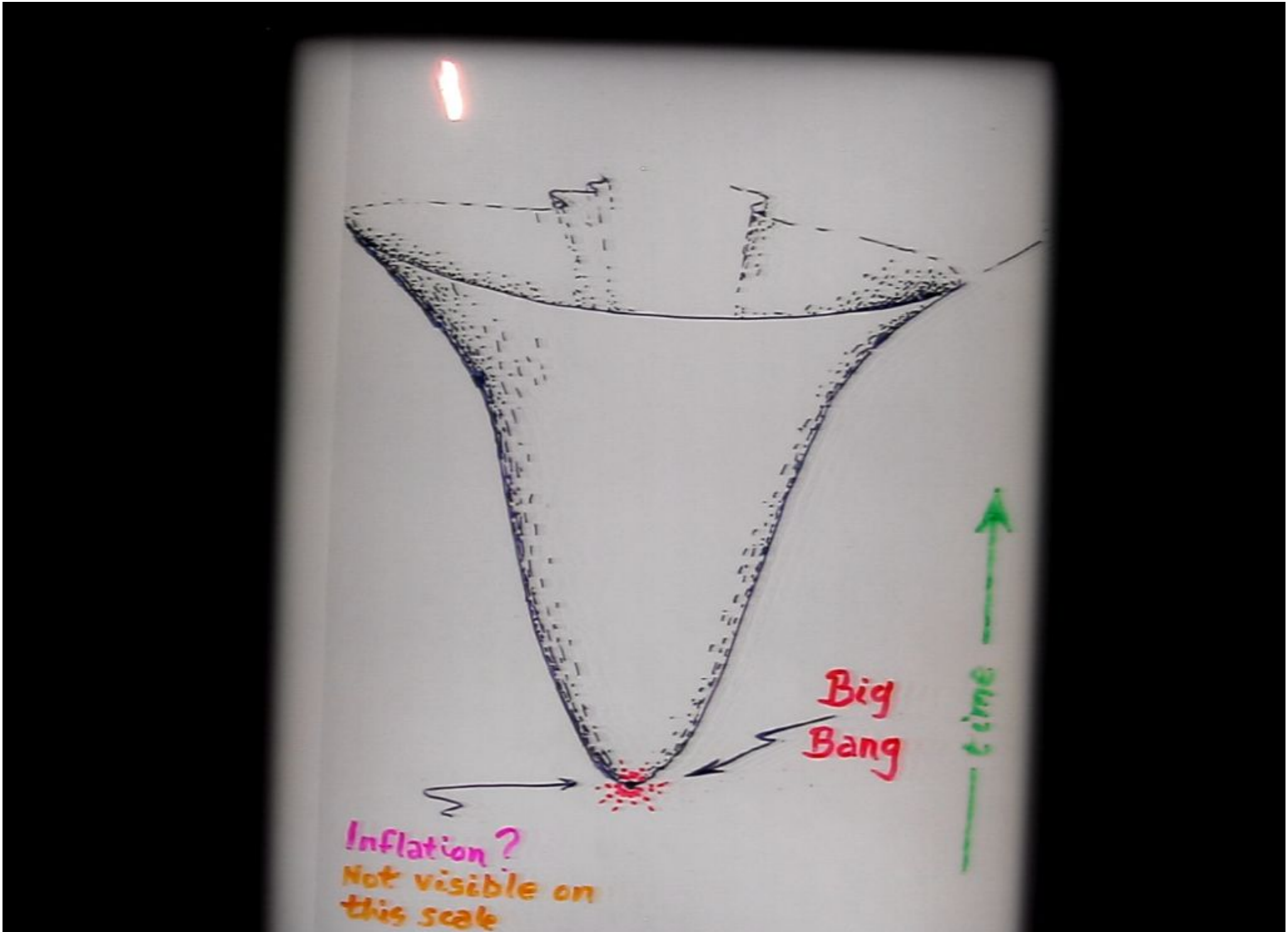
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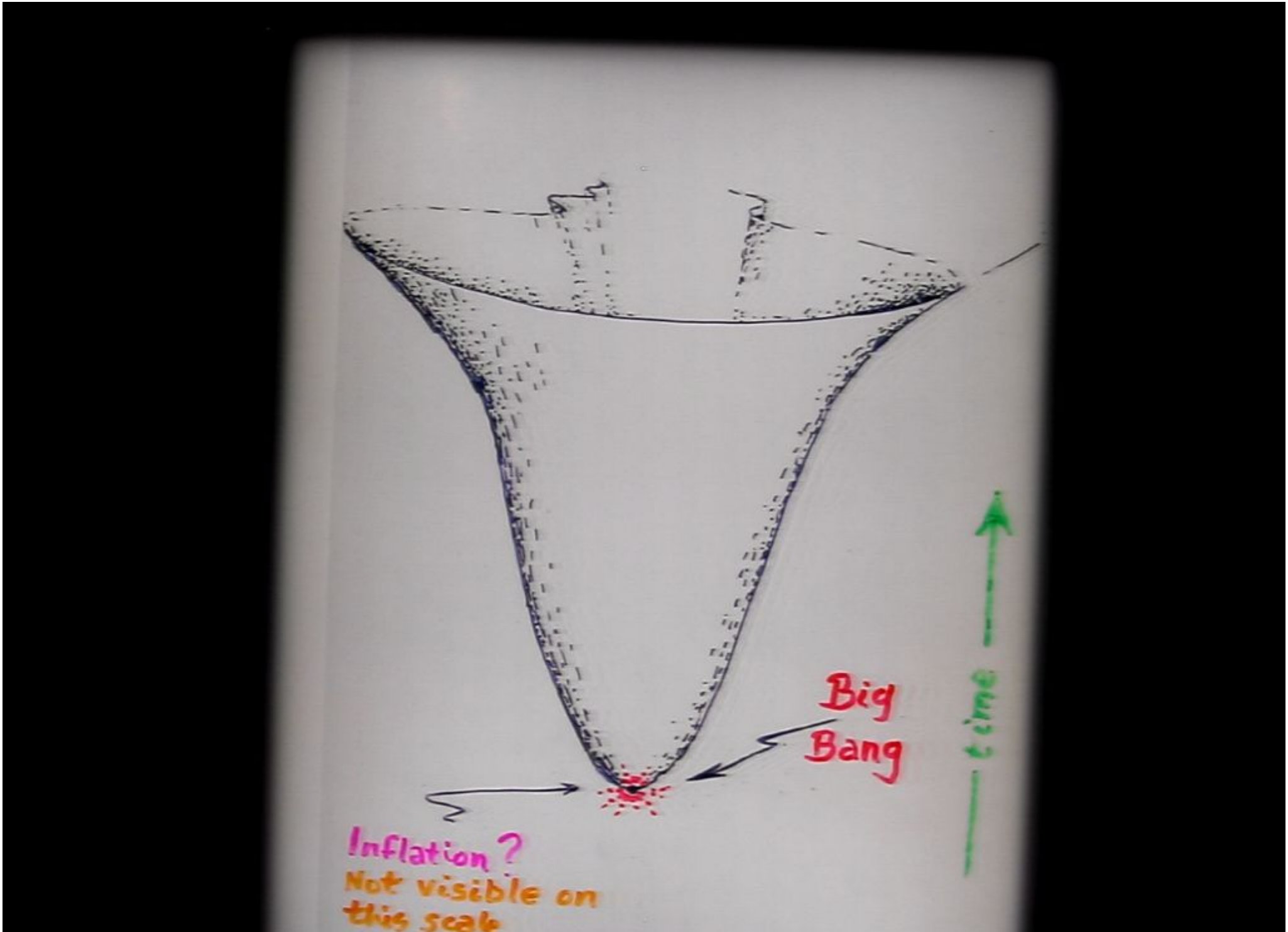
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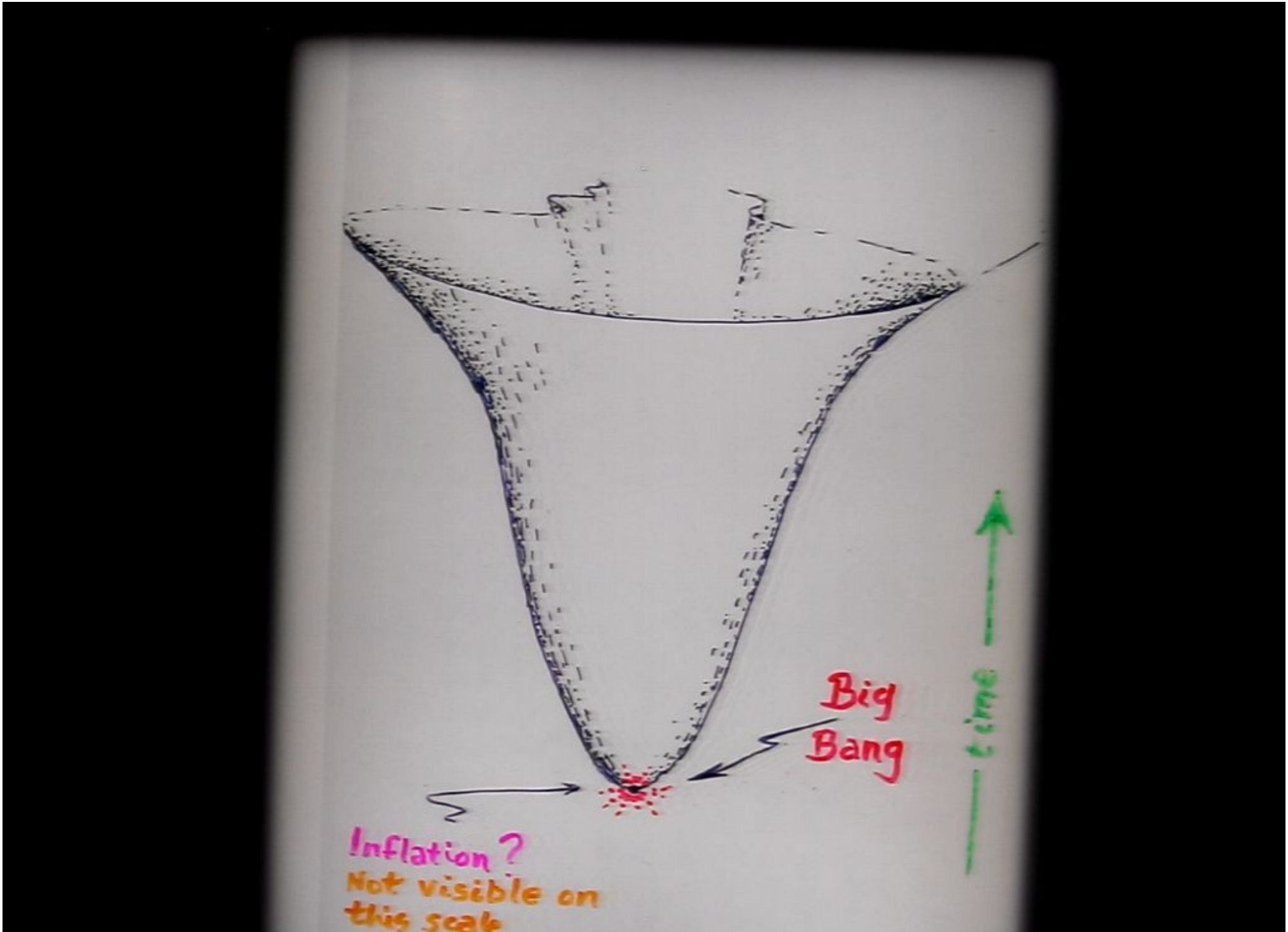
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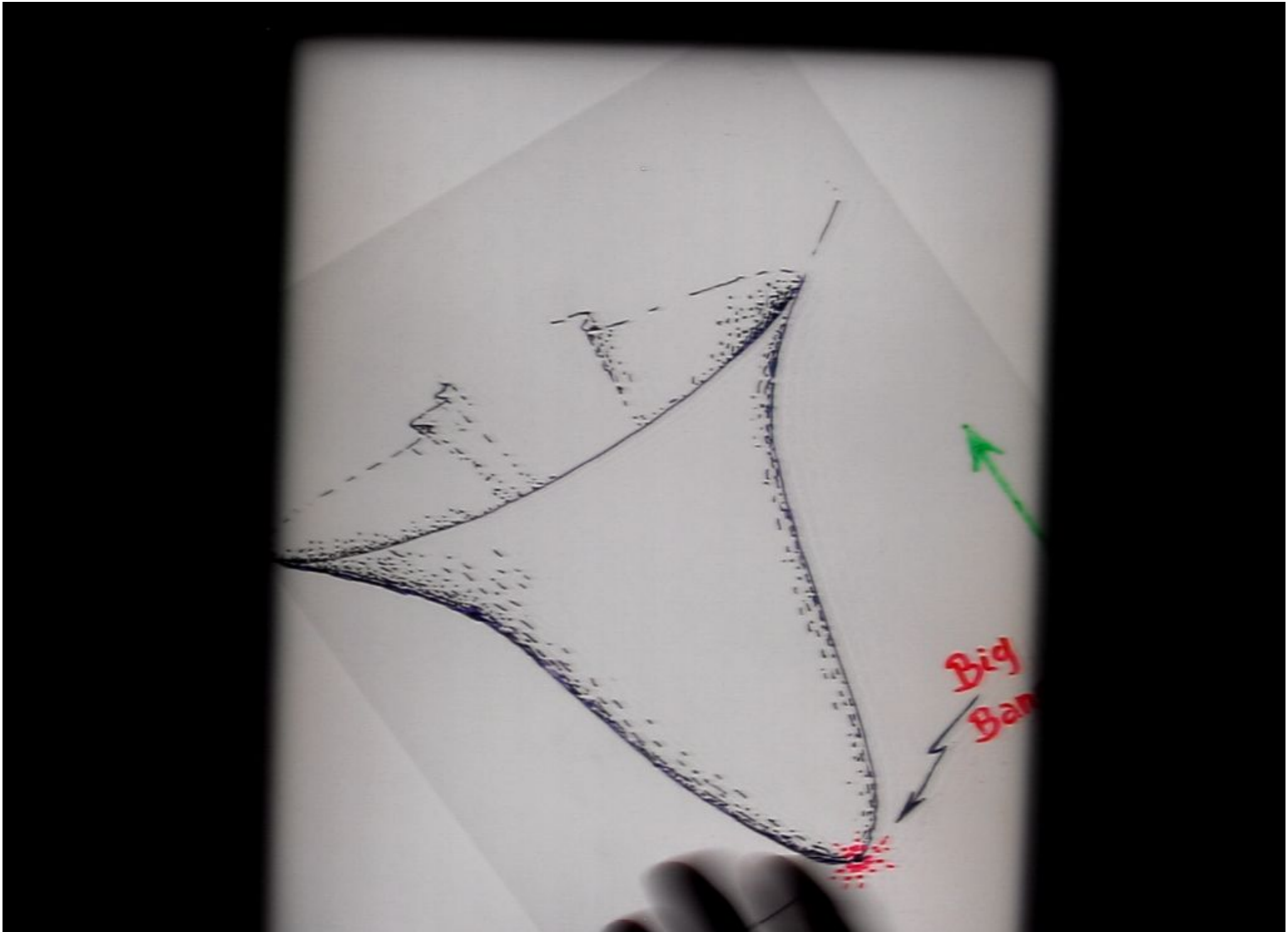
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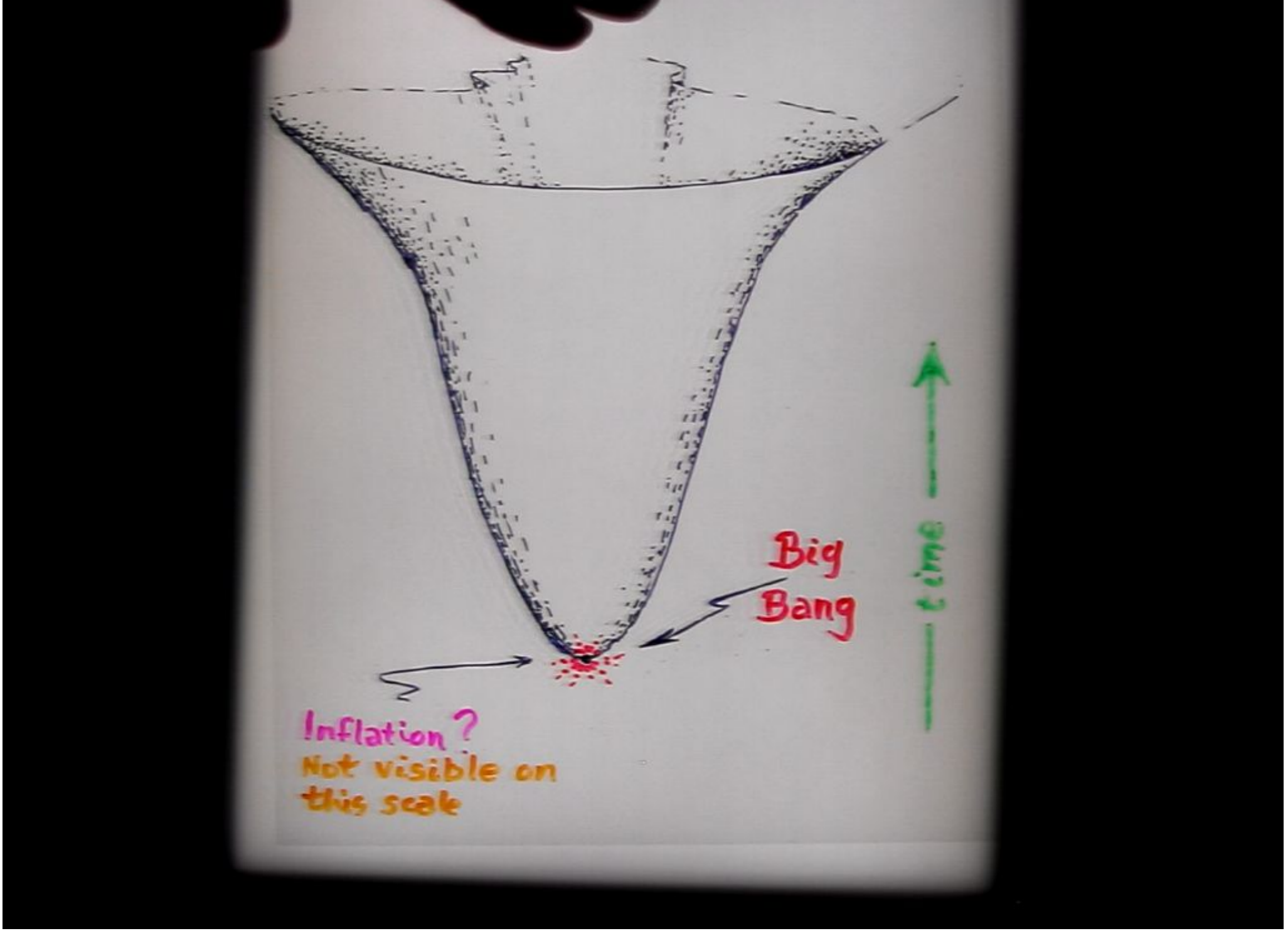
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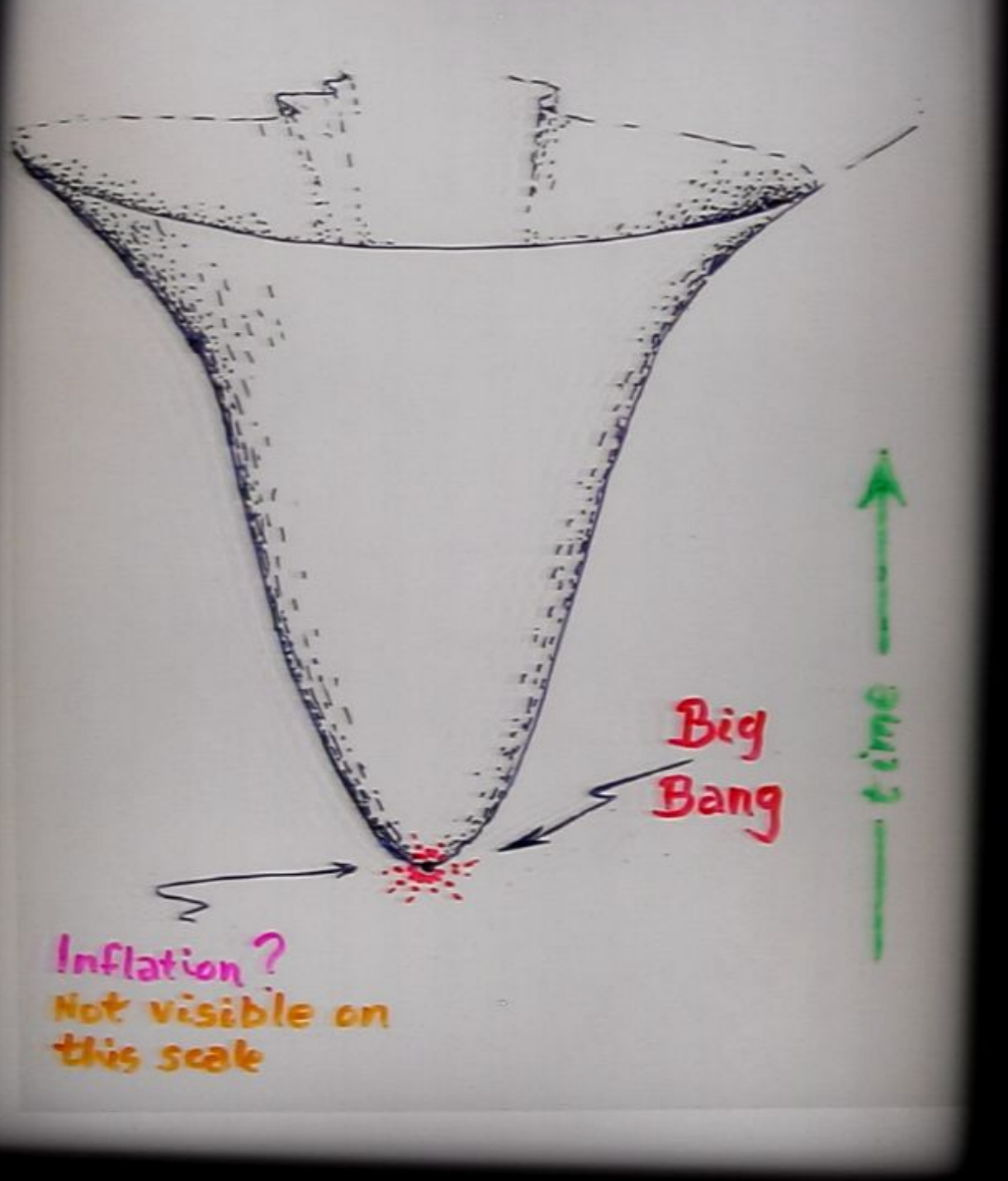
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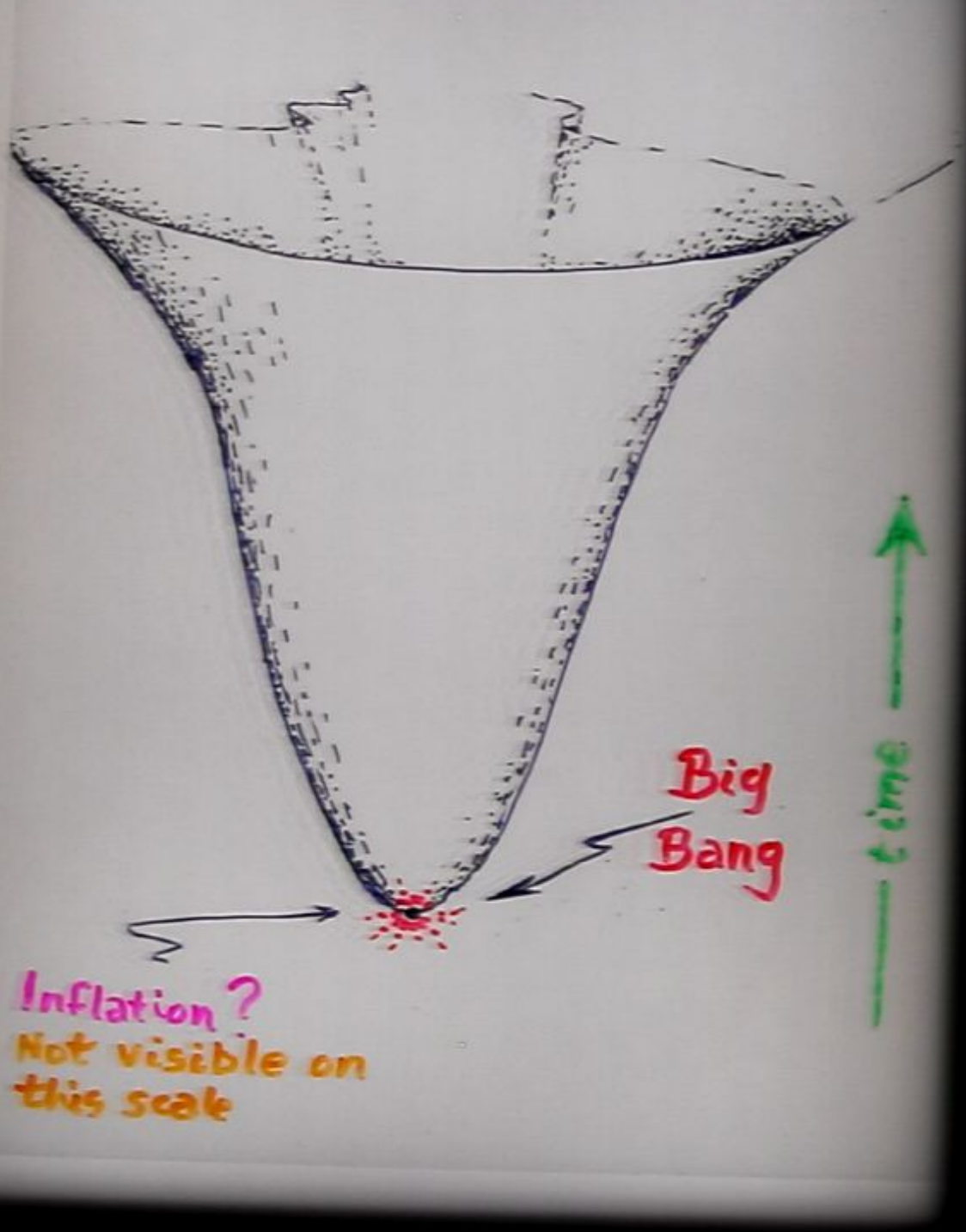
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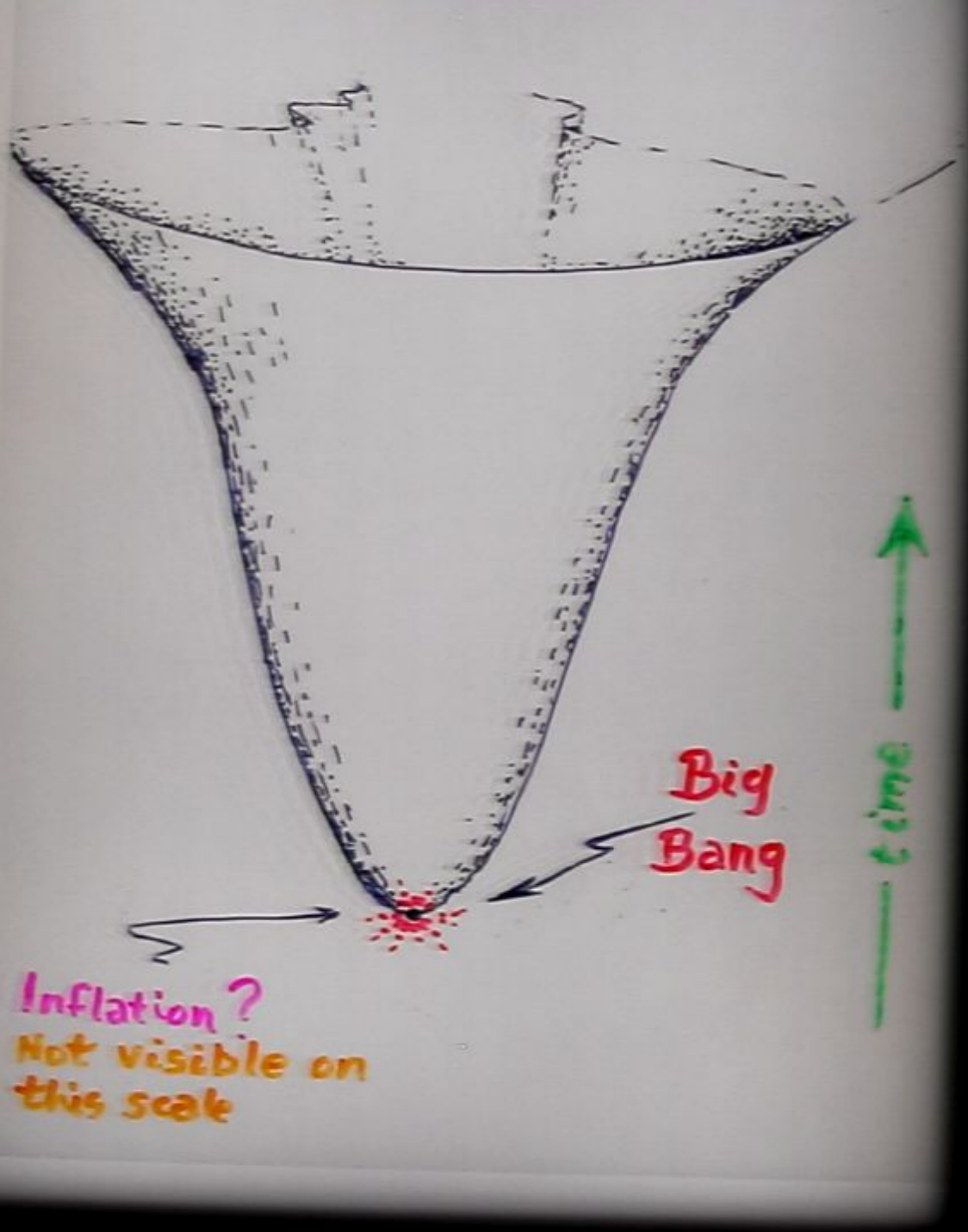
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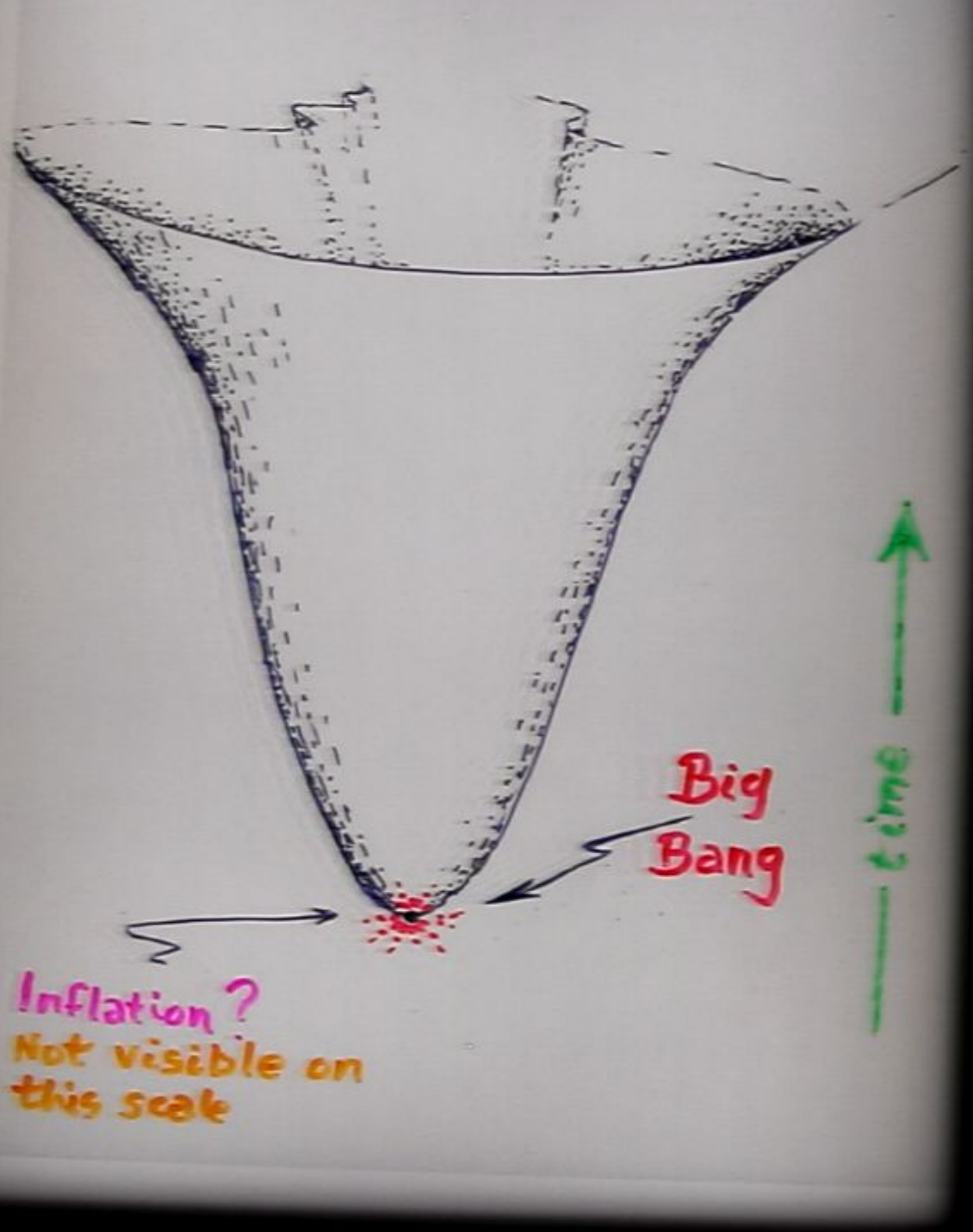
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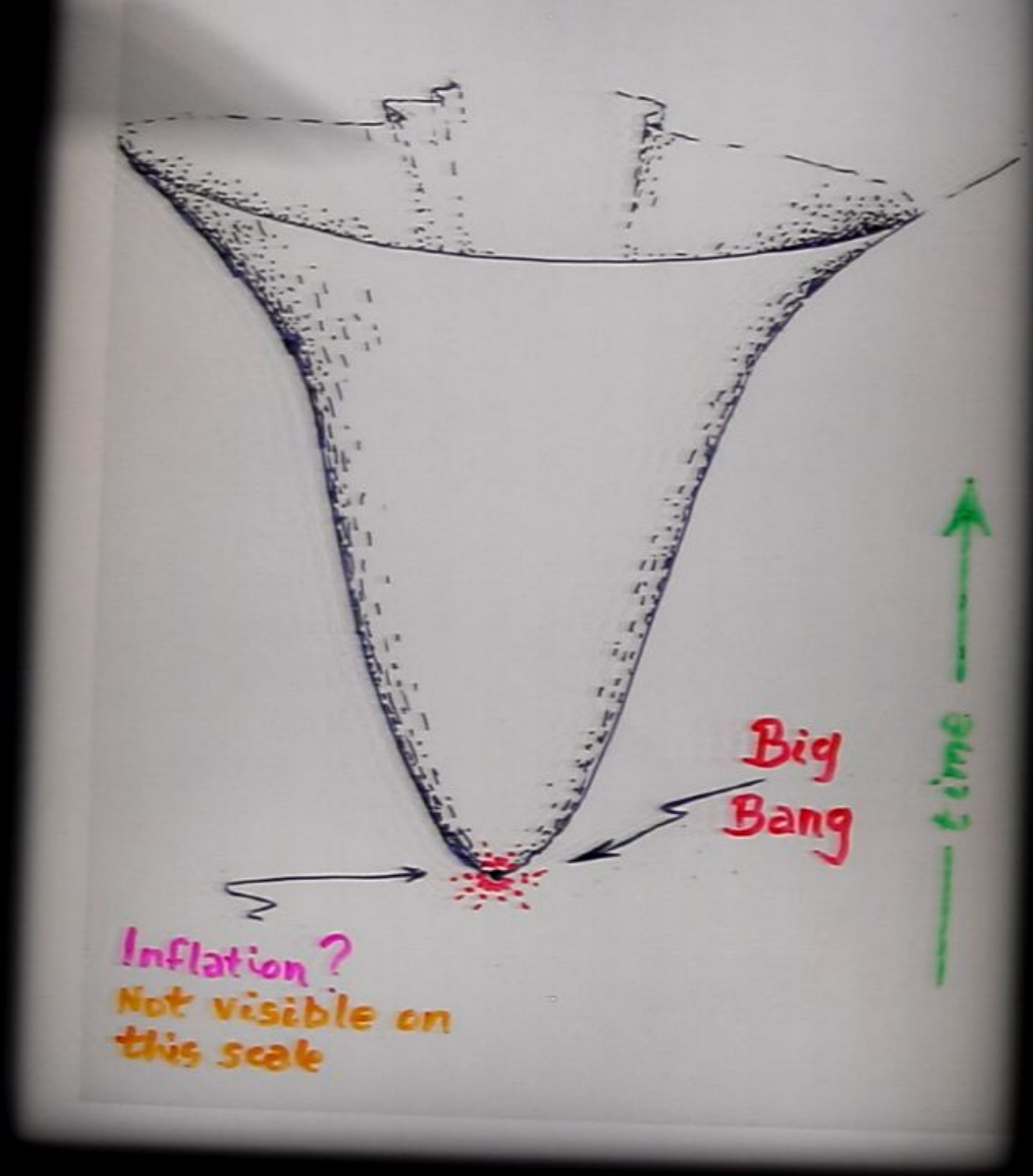
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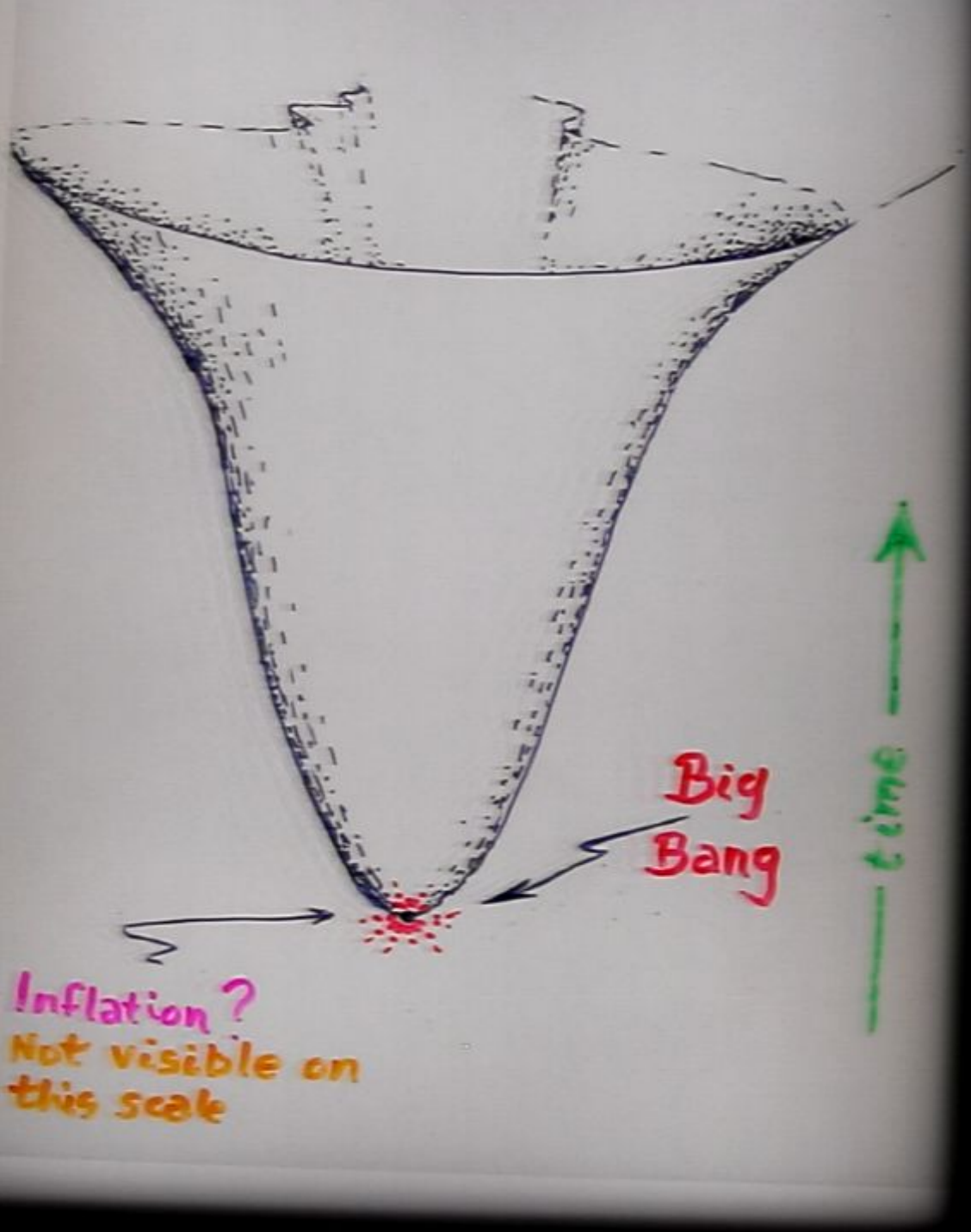
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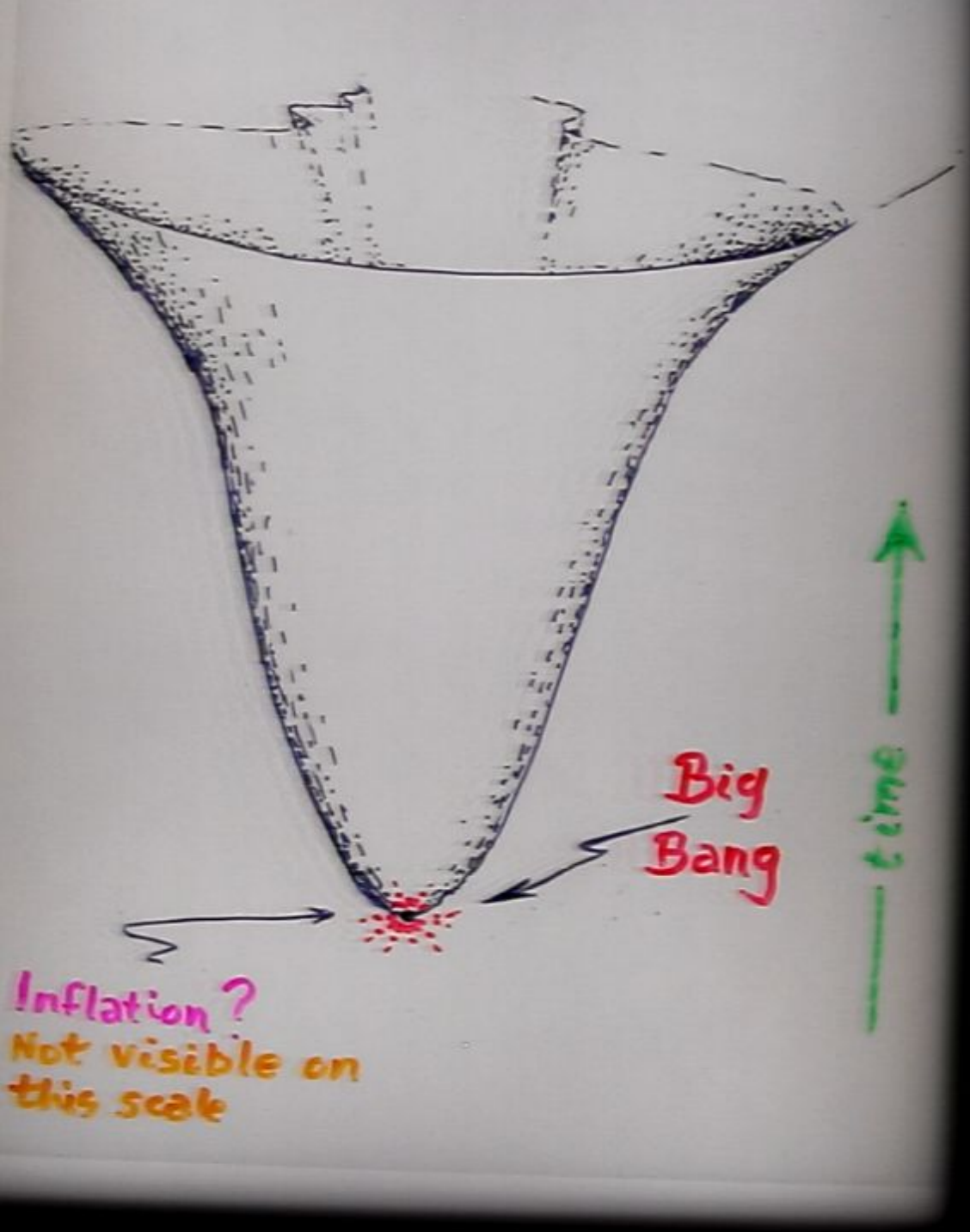
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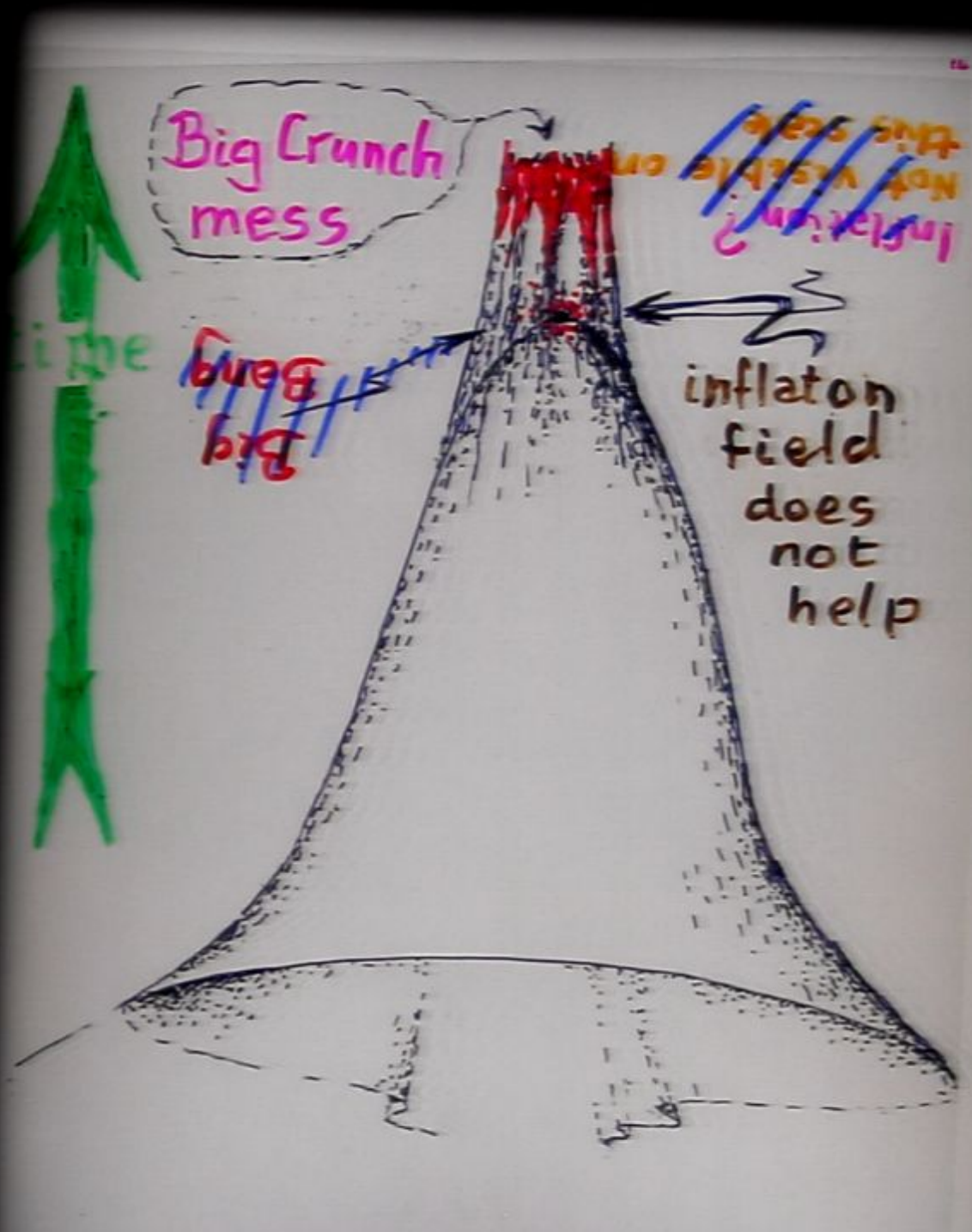
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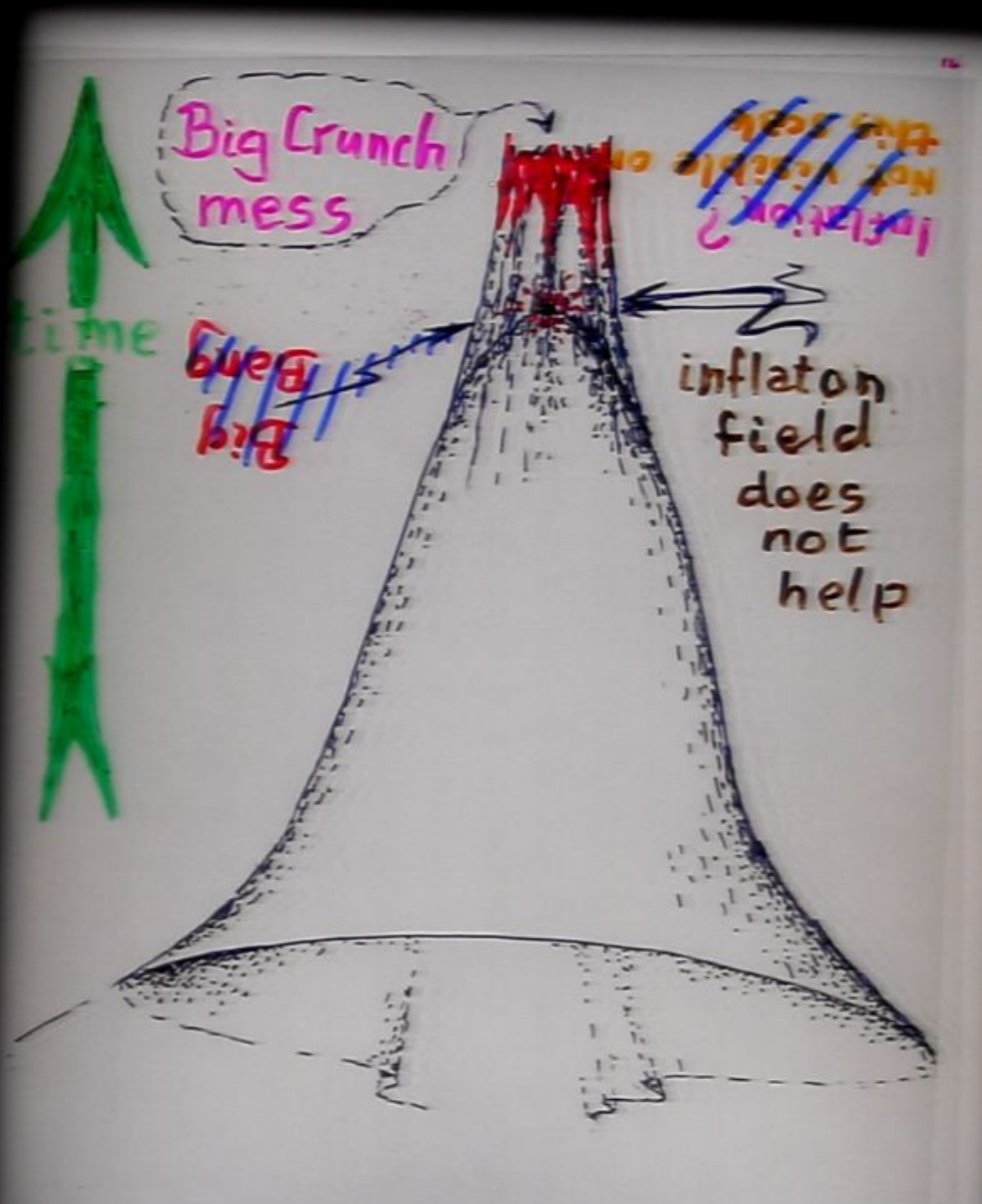
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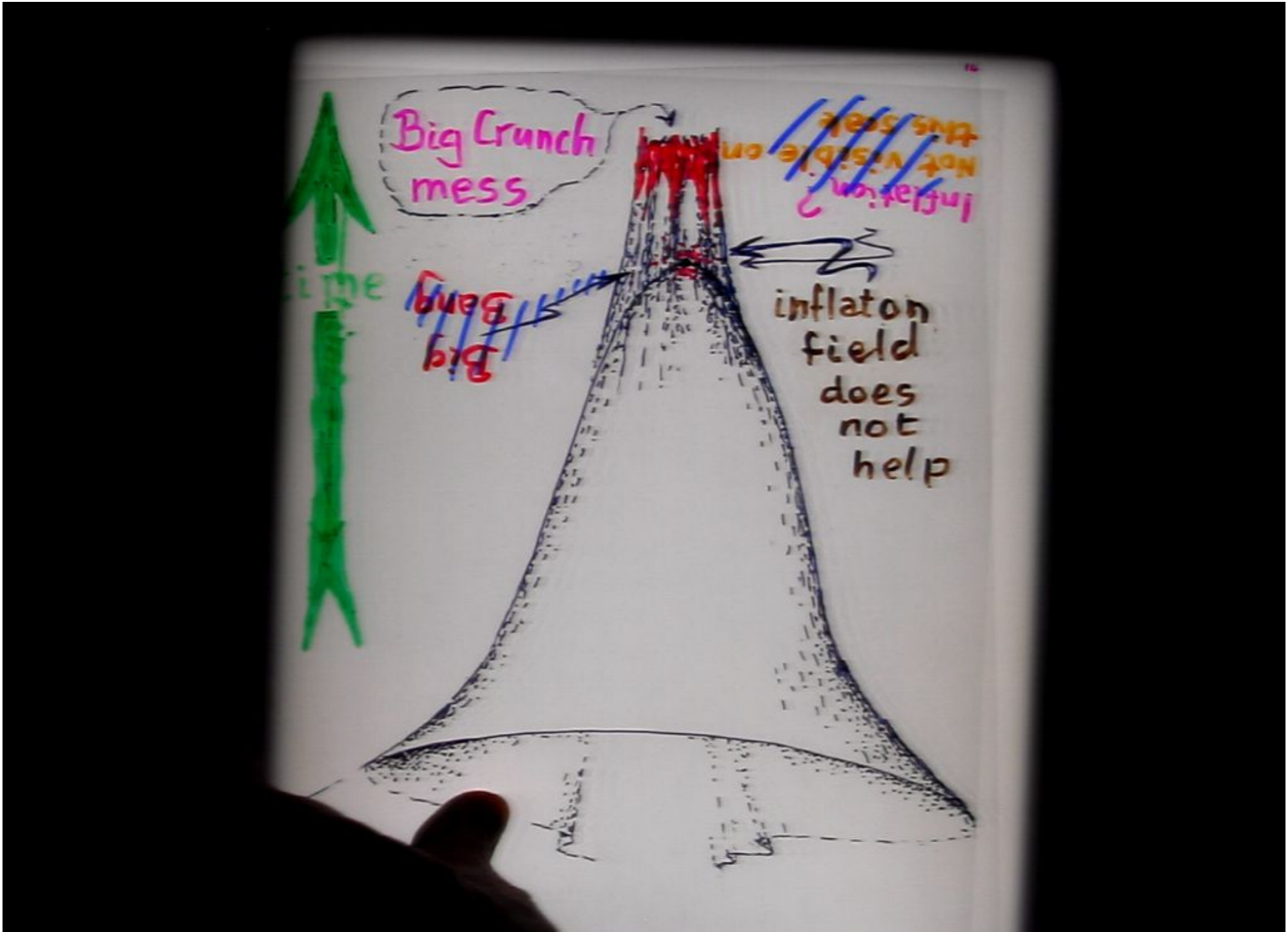
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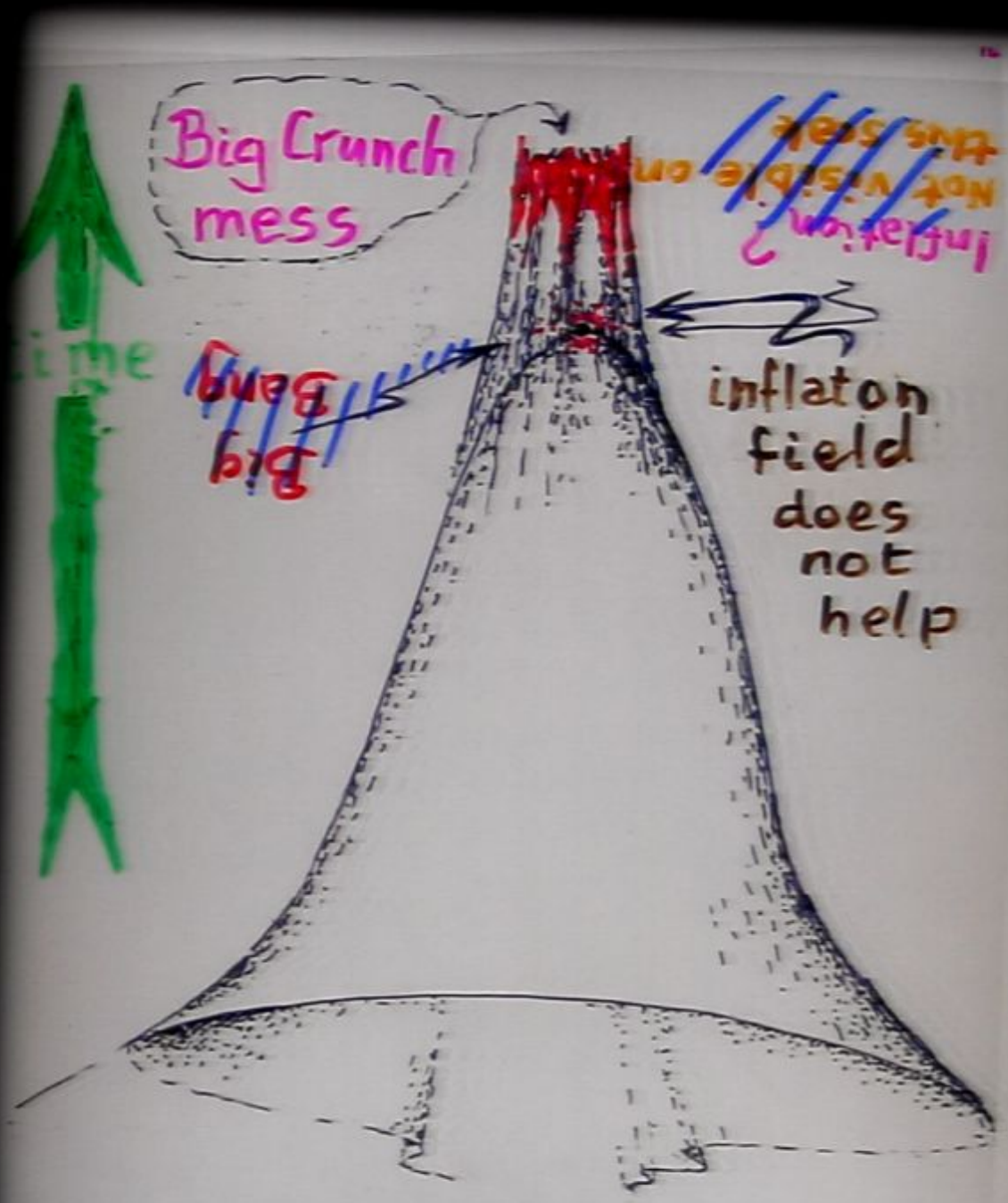
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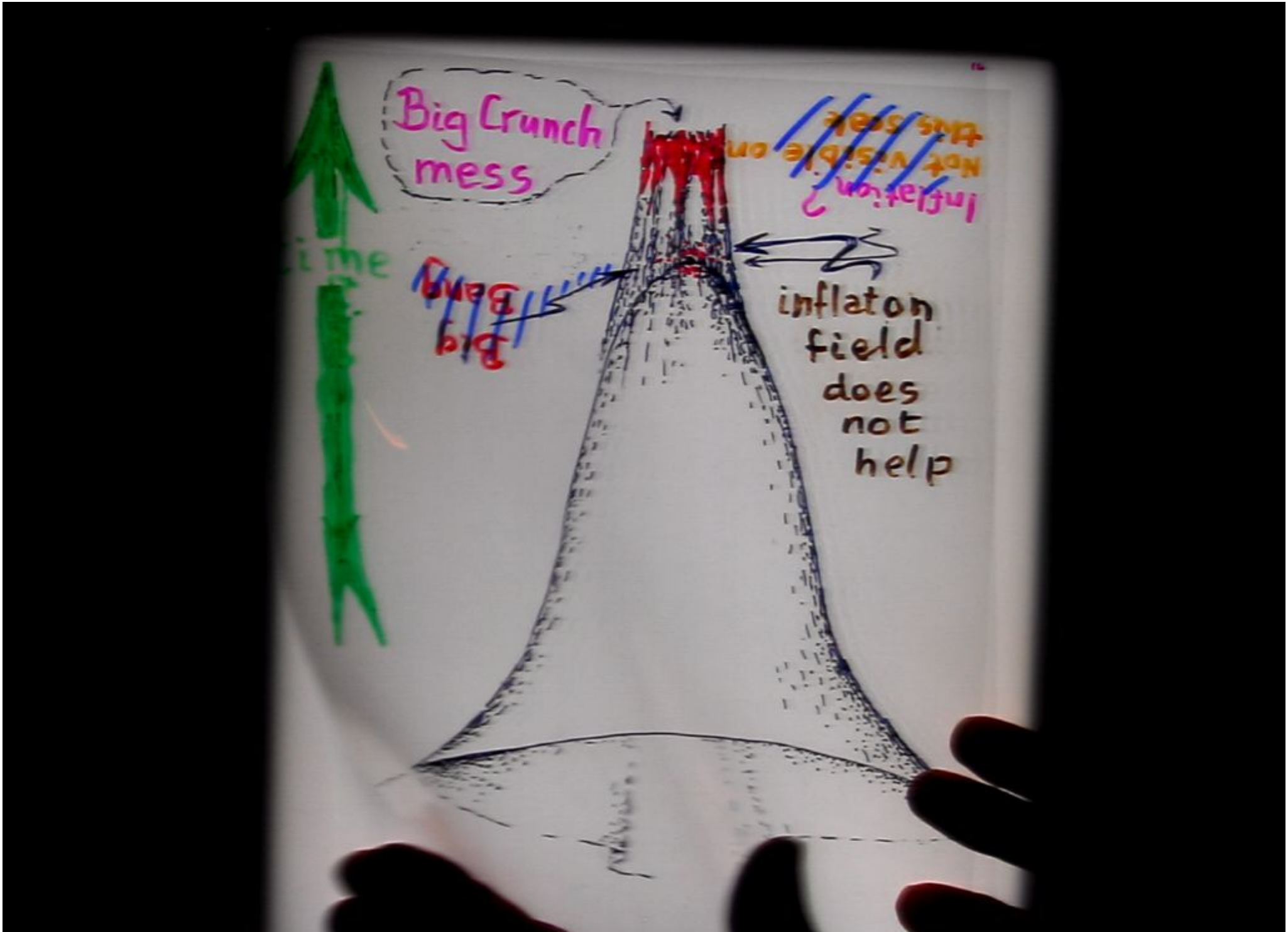
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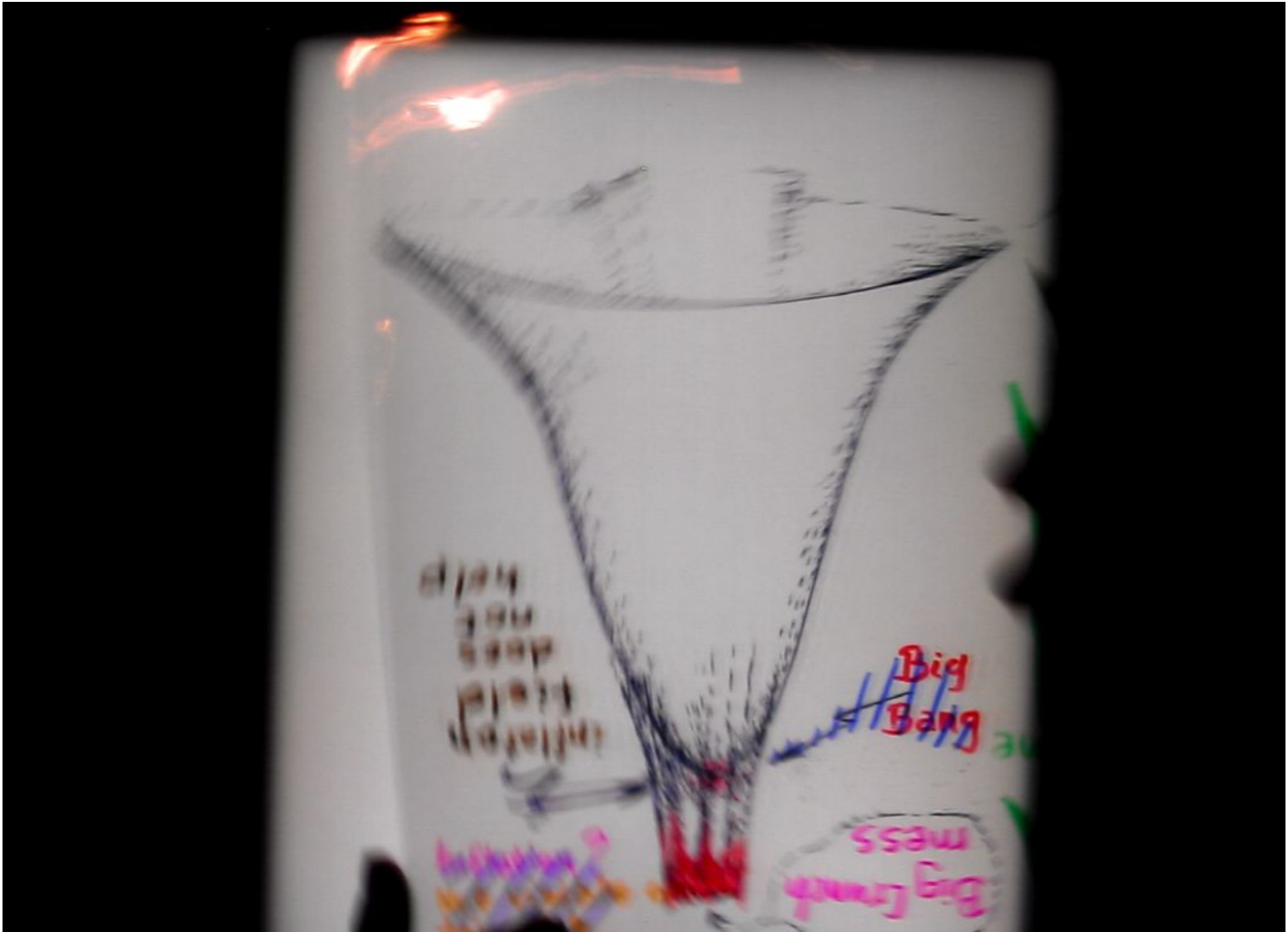
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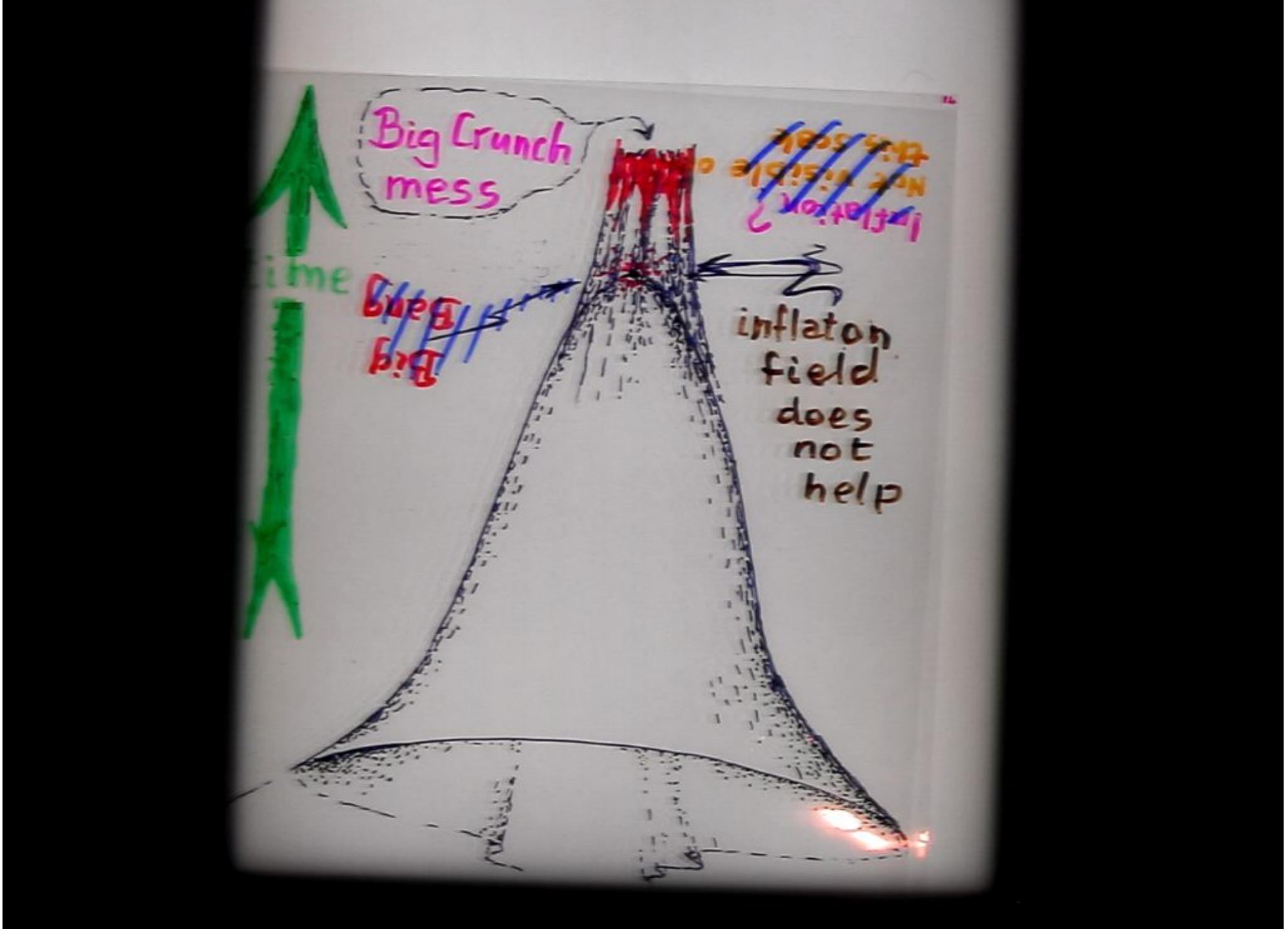
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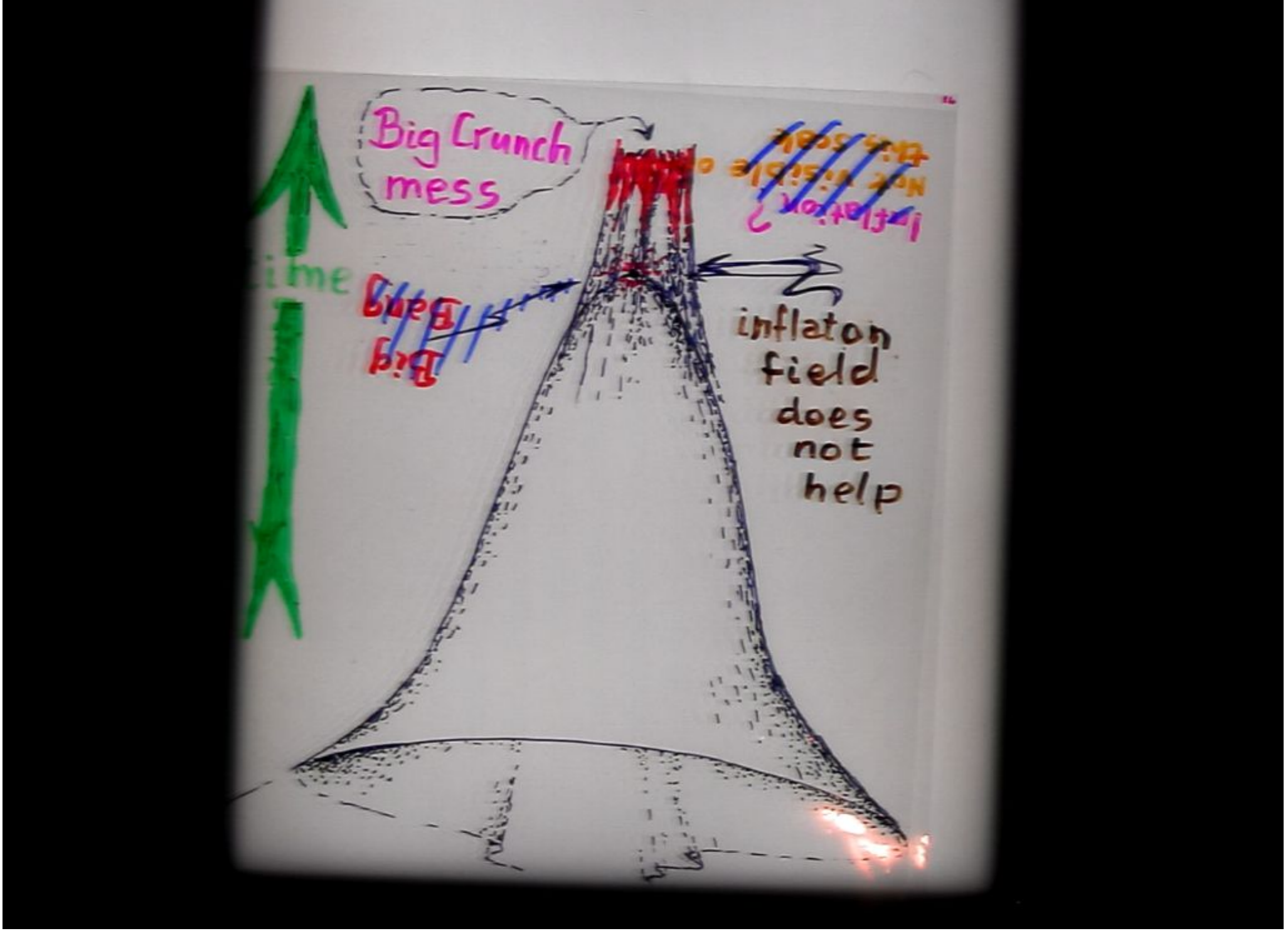
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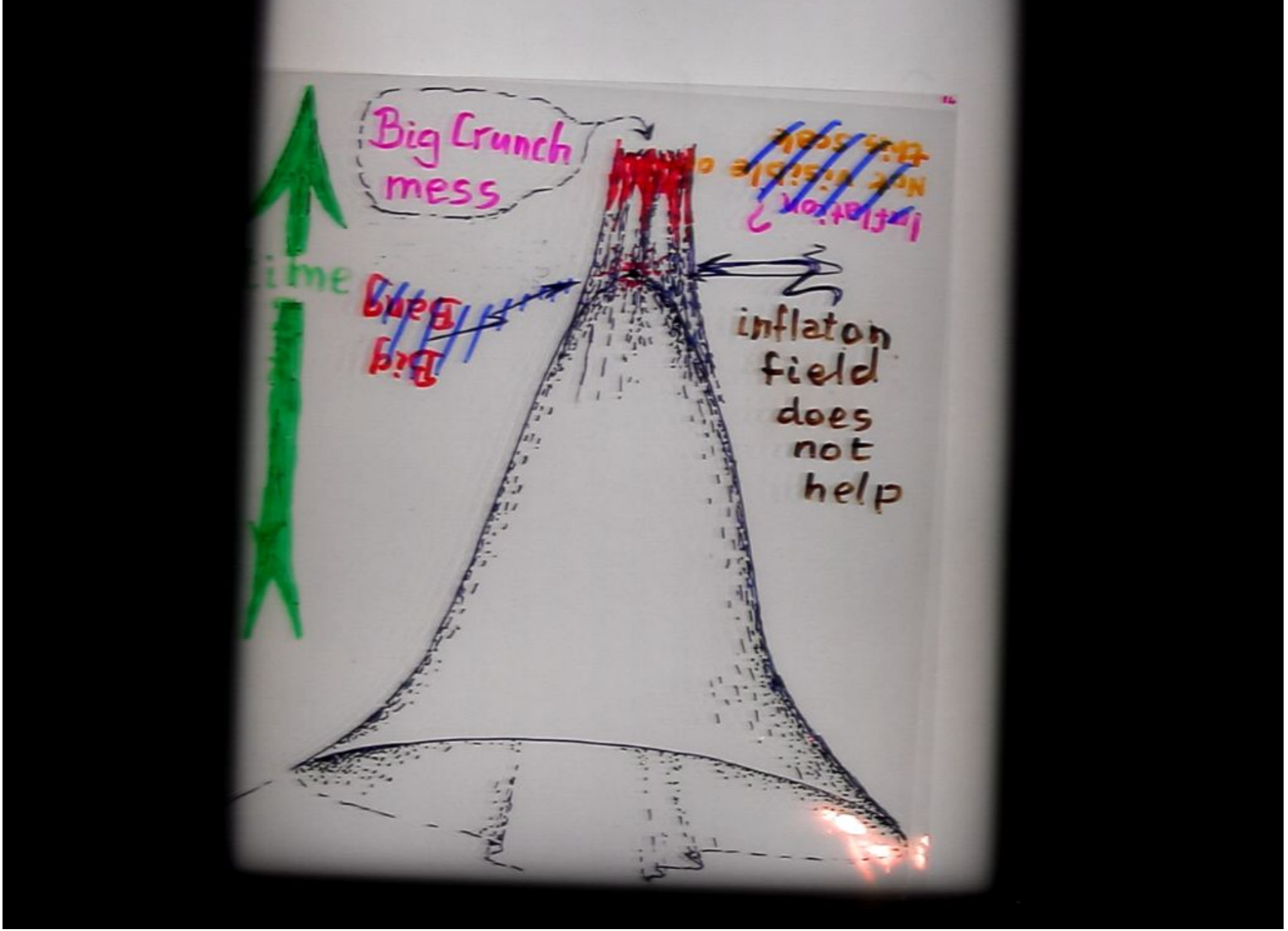
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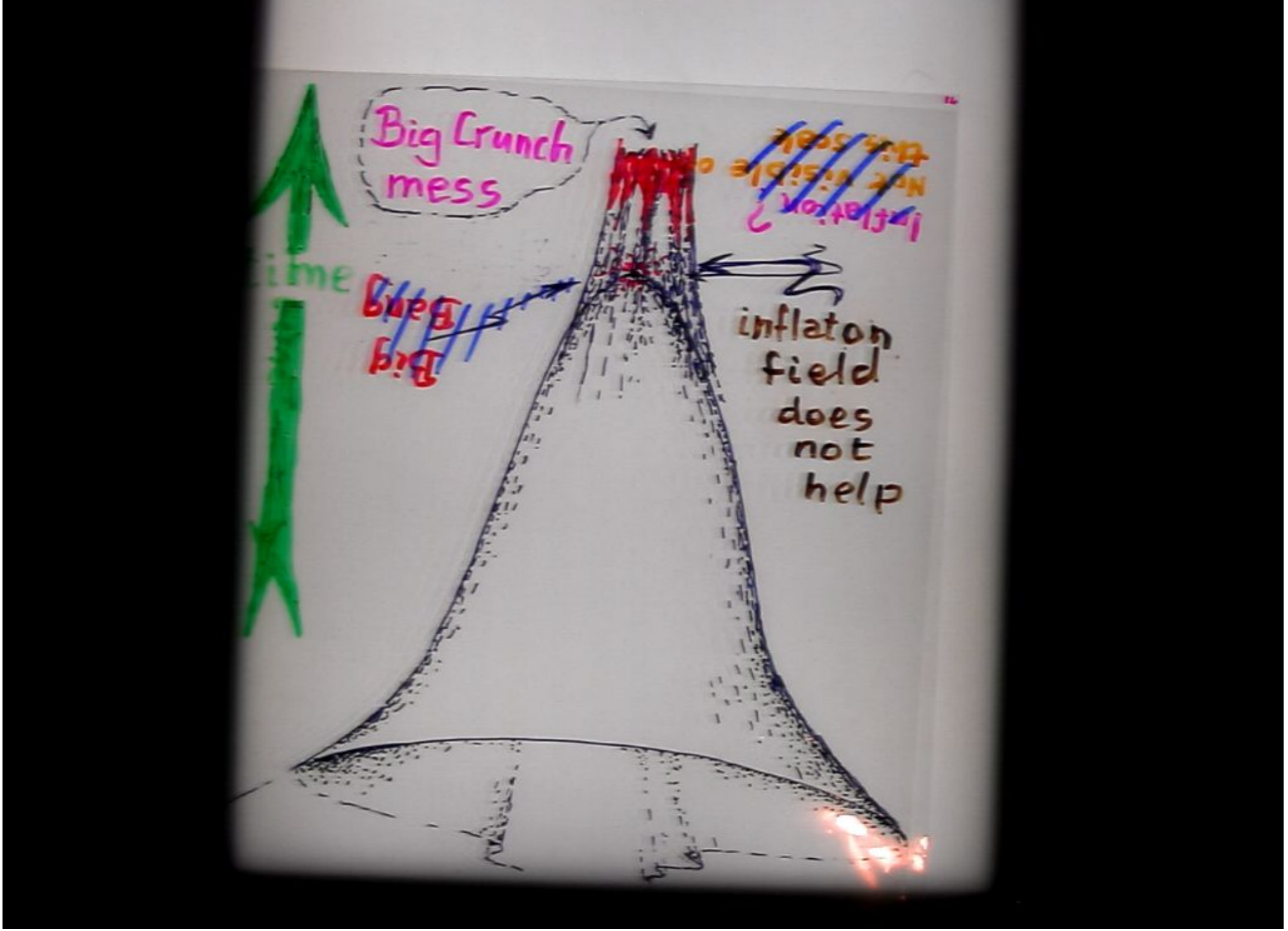
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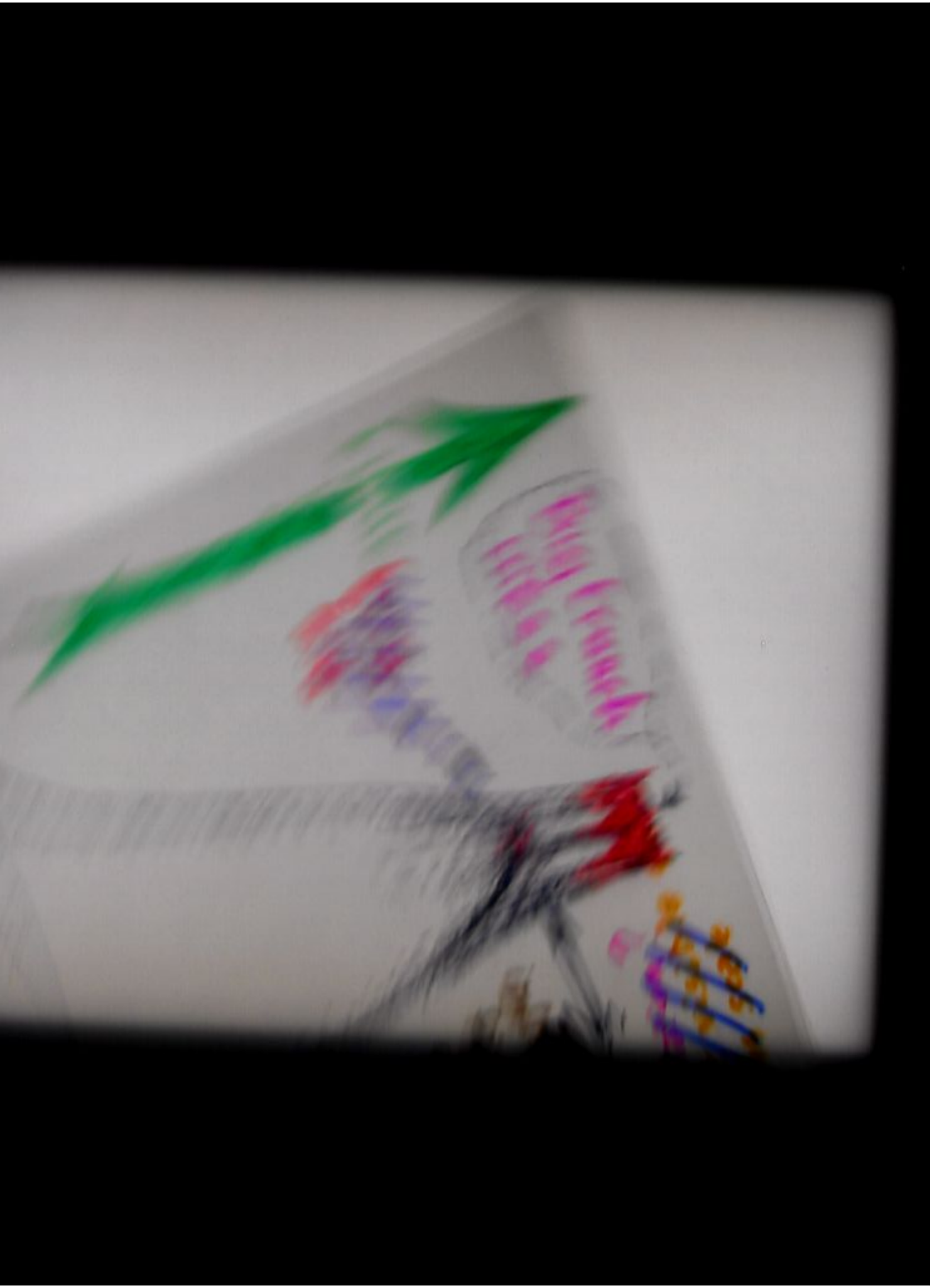

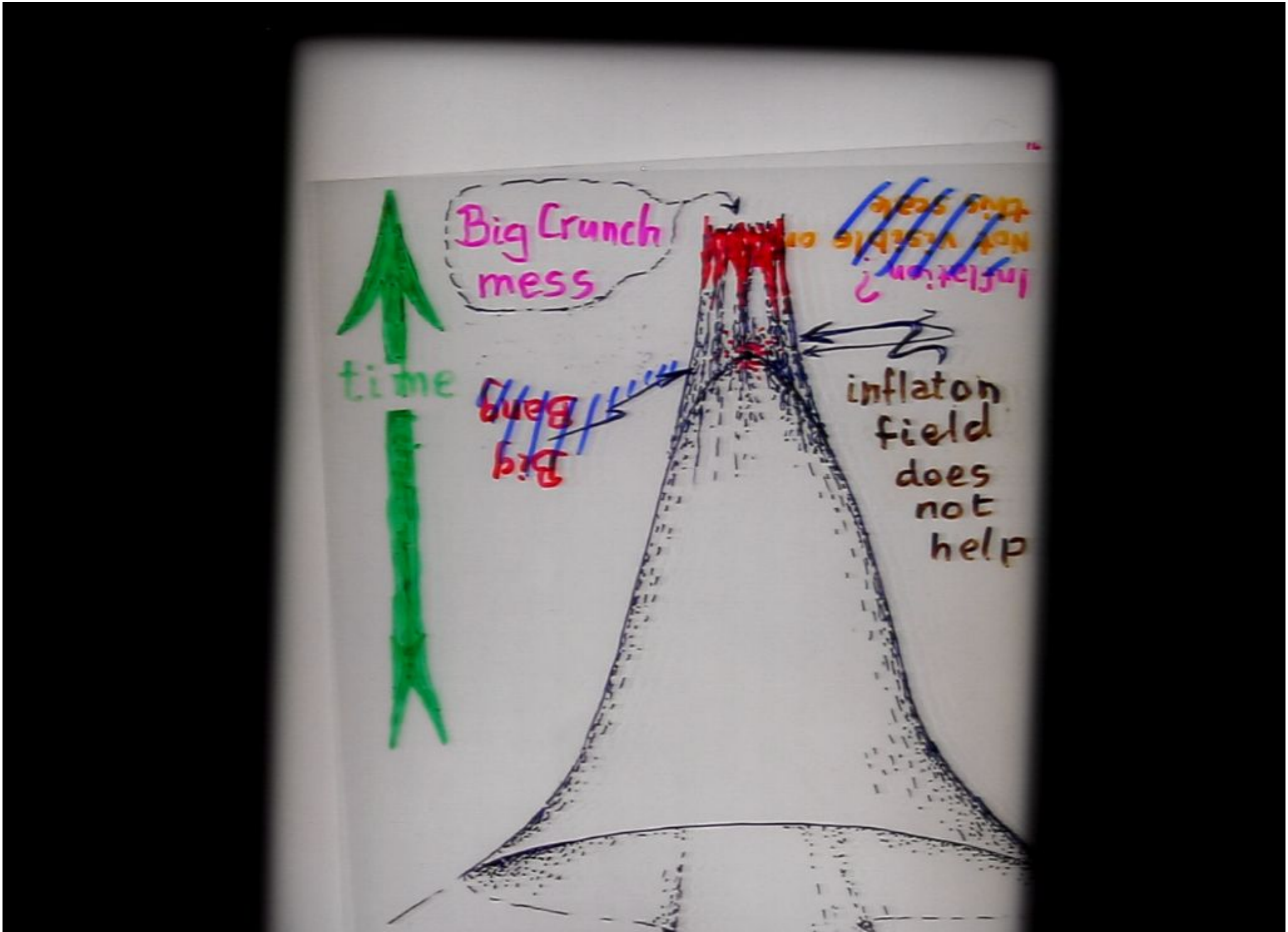
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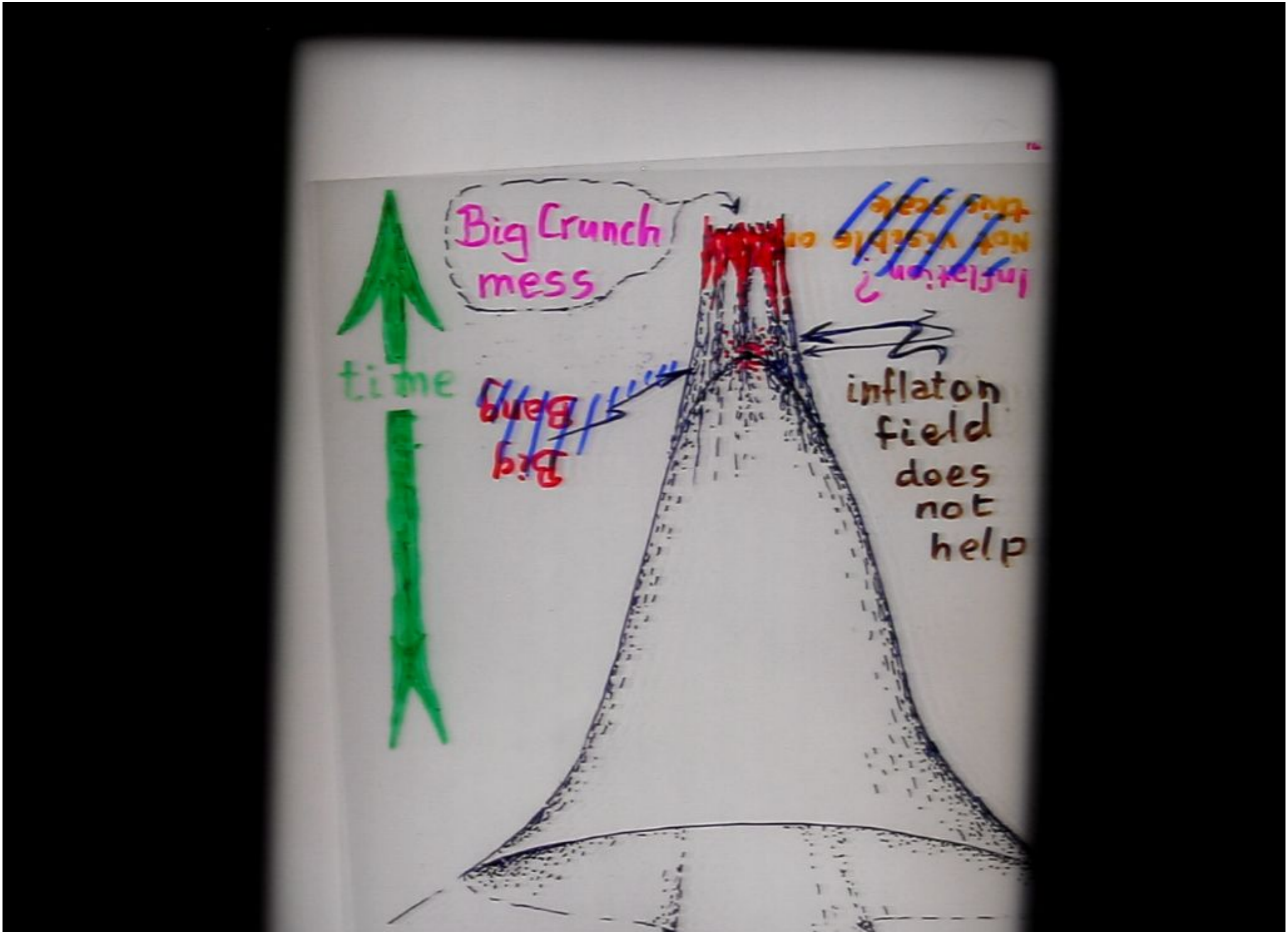
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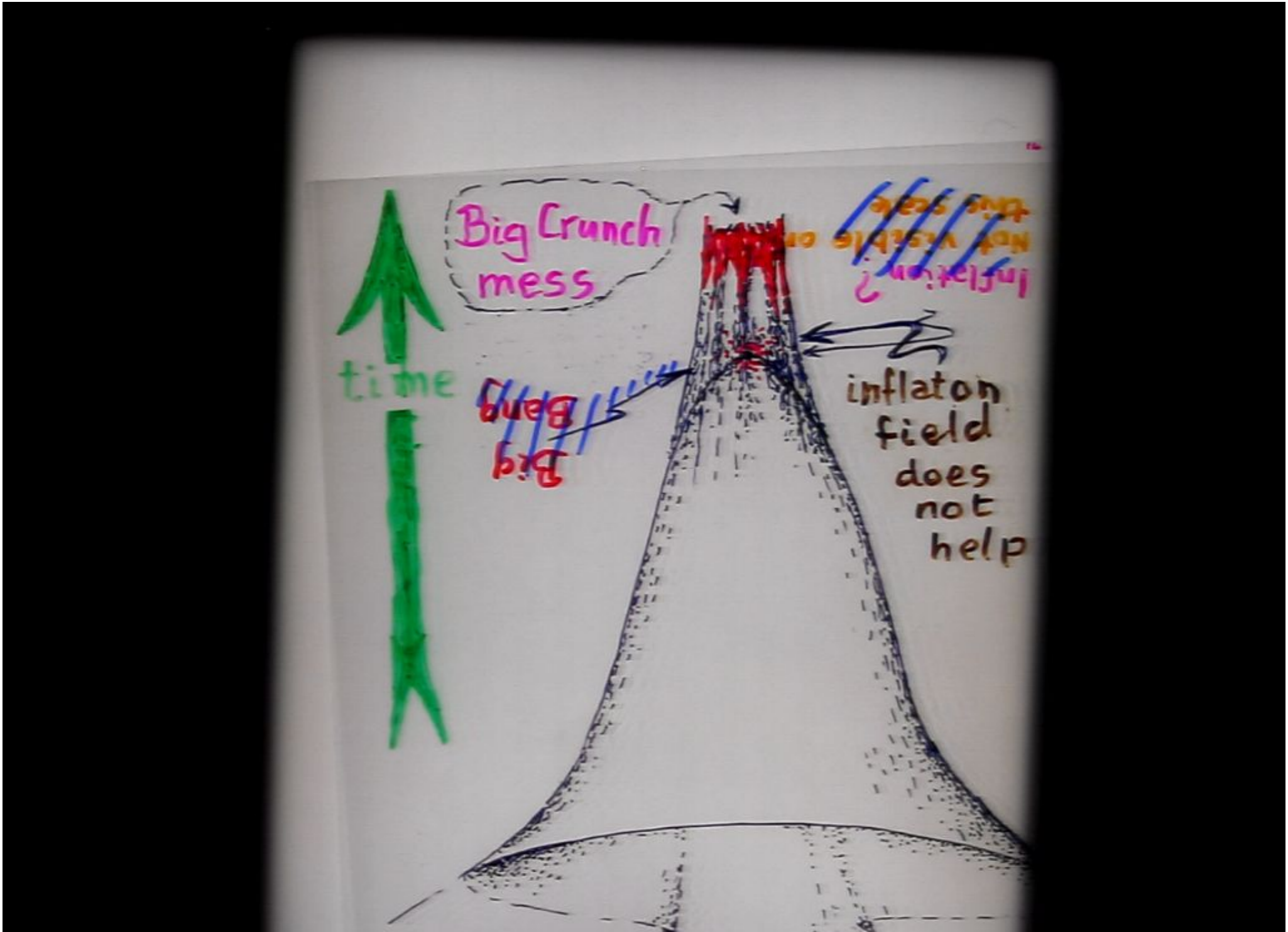
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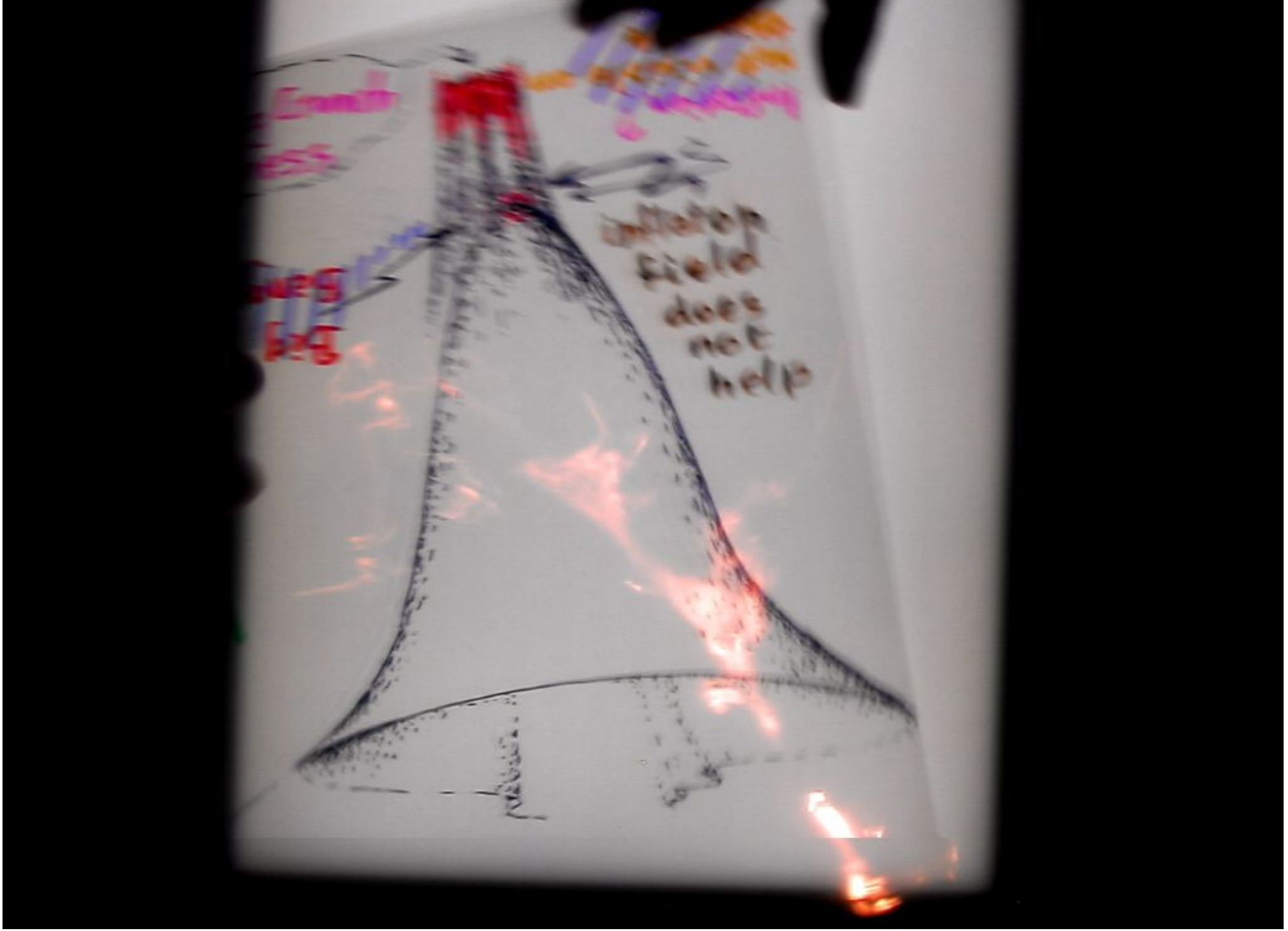
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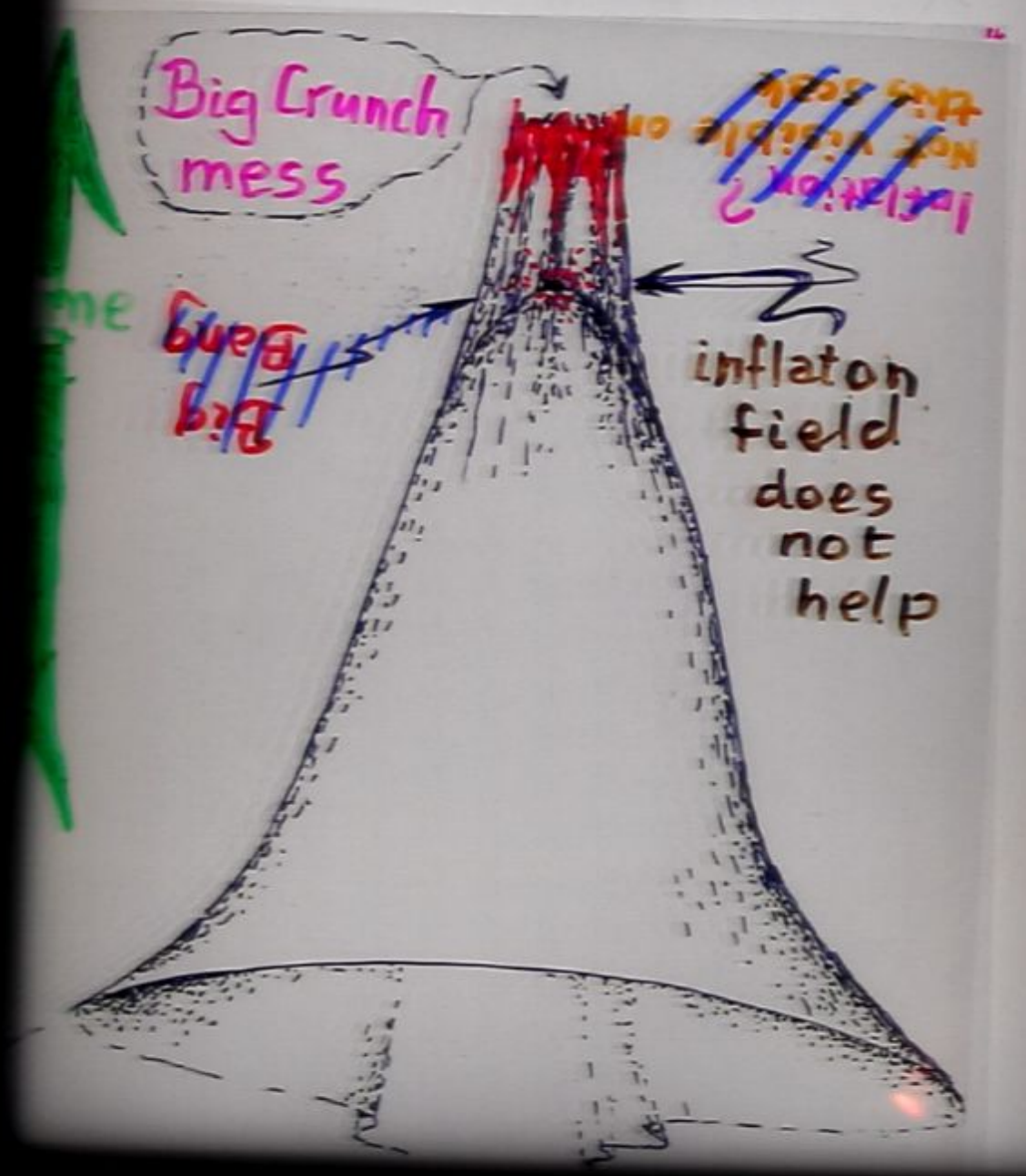
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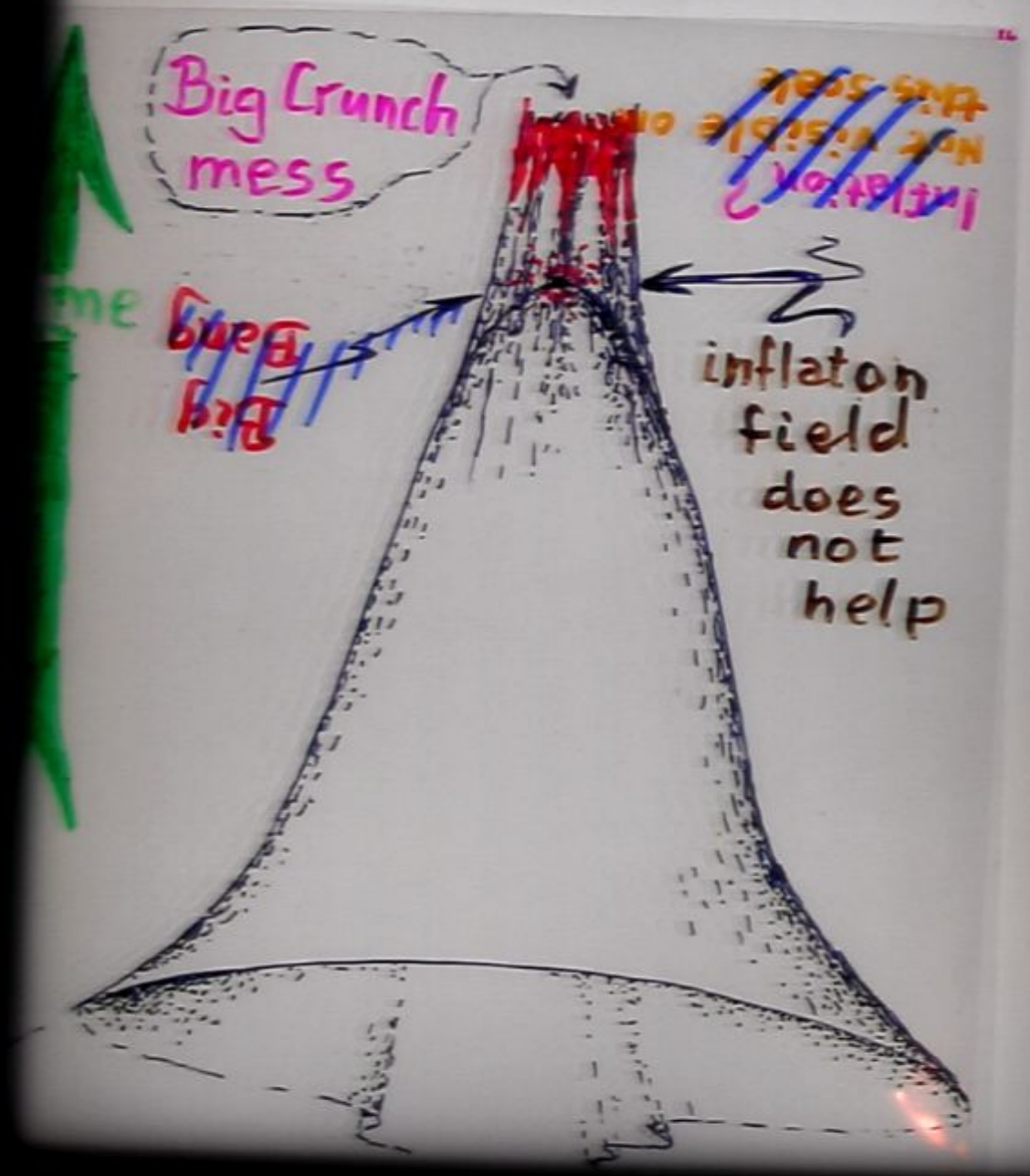
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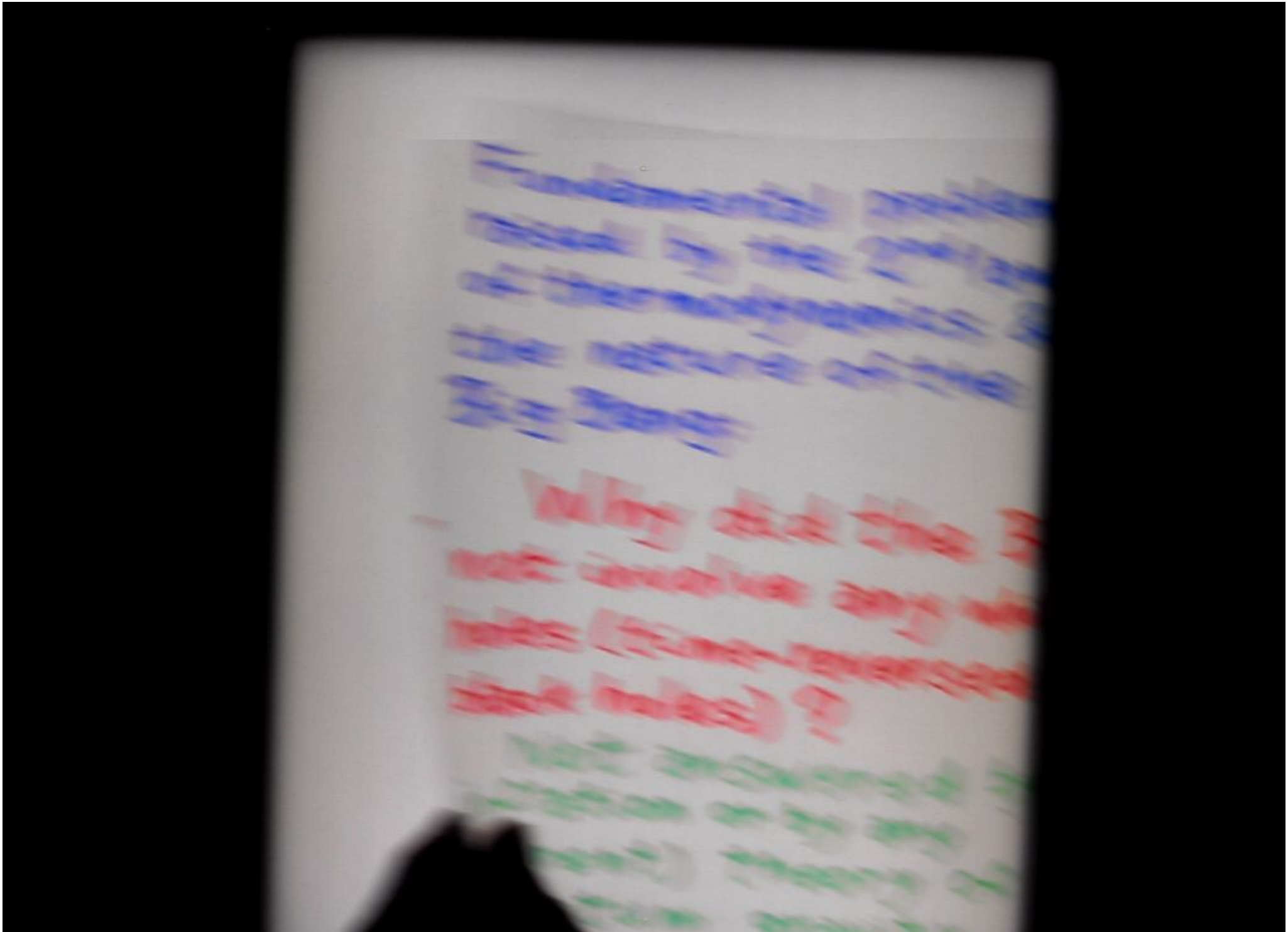

Fundamental problem raised by the 2nd law of thermodynamics & the nature of the Big Bang:

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

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

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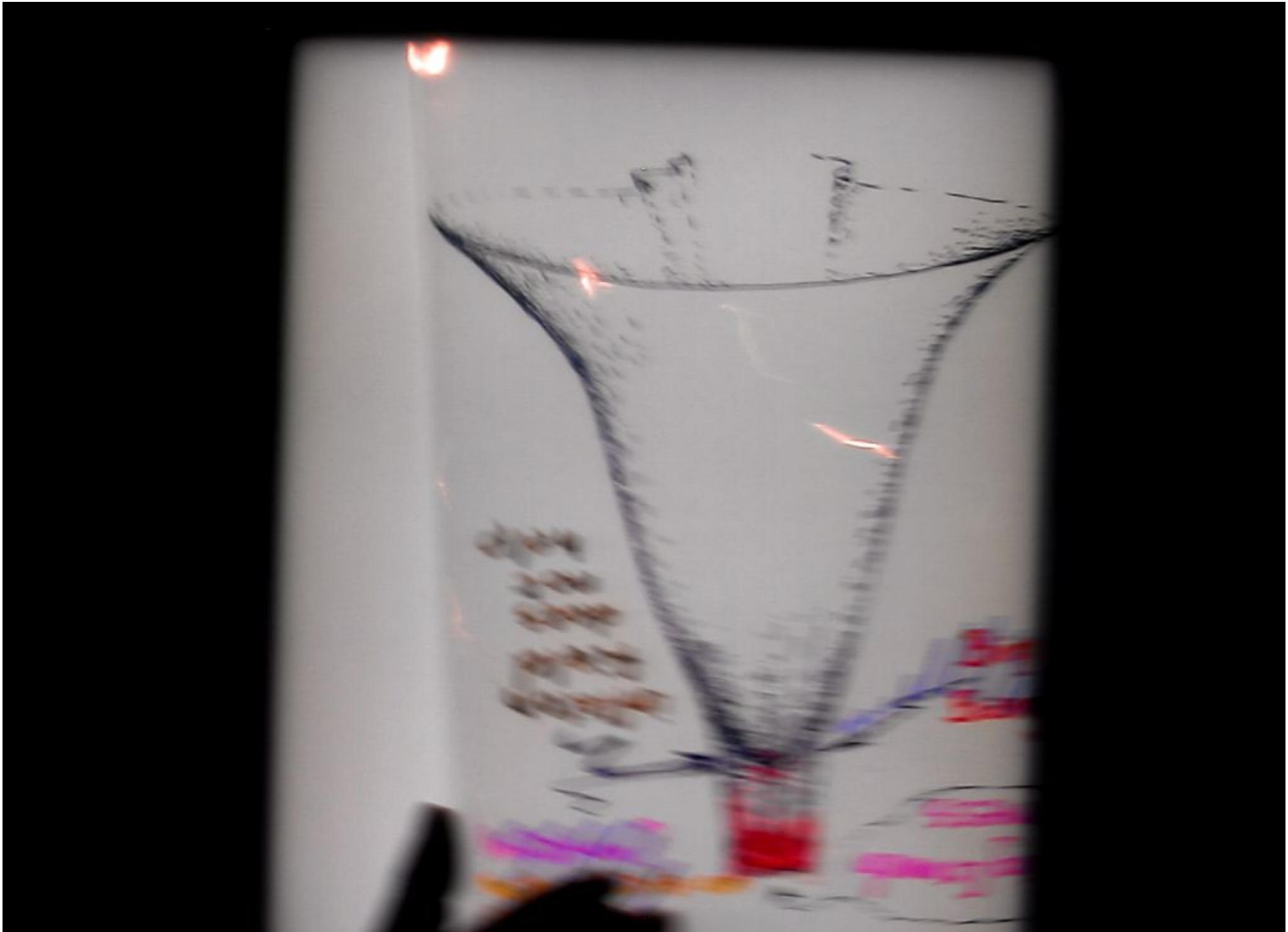

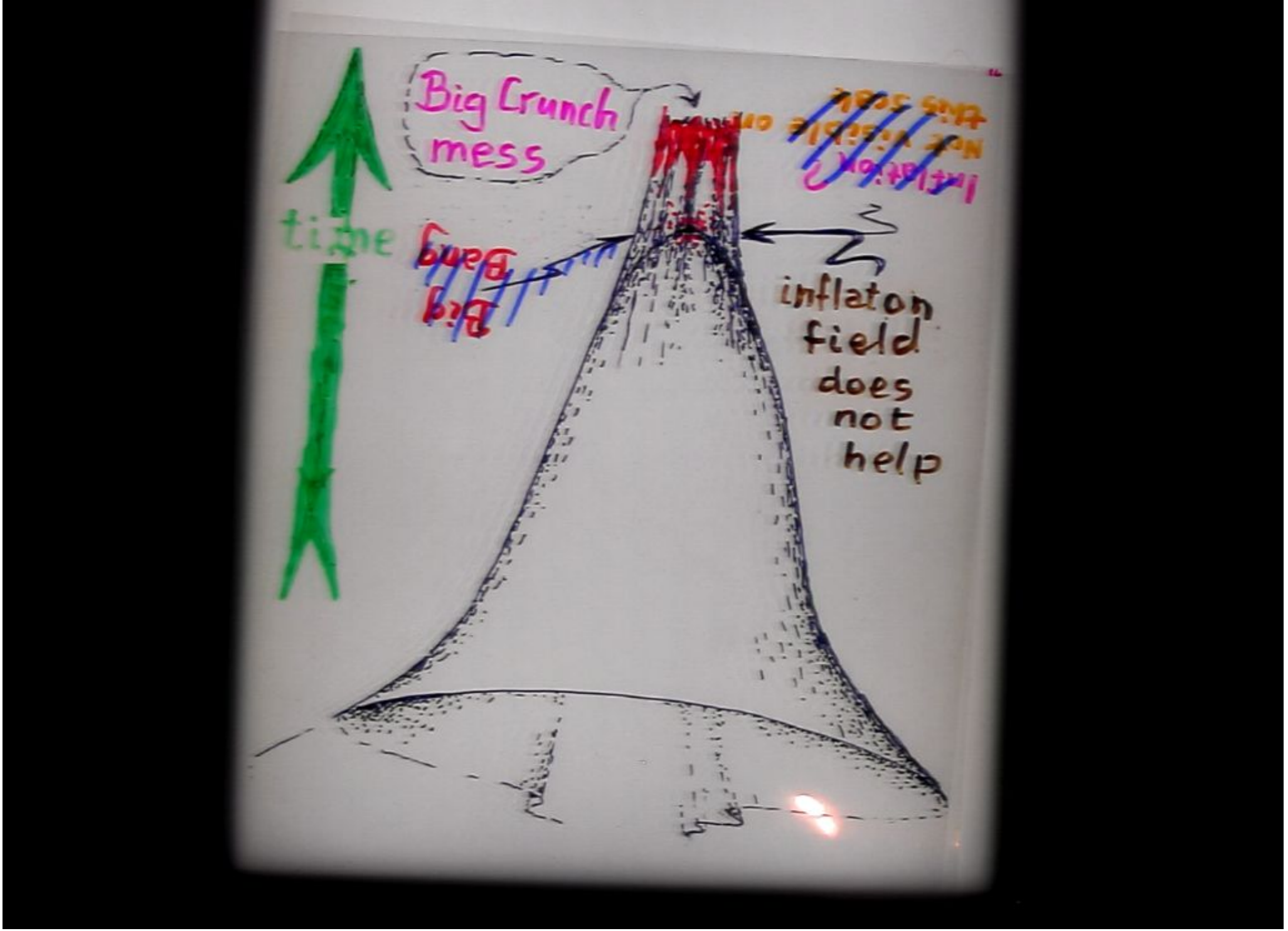
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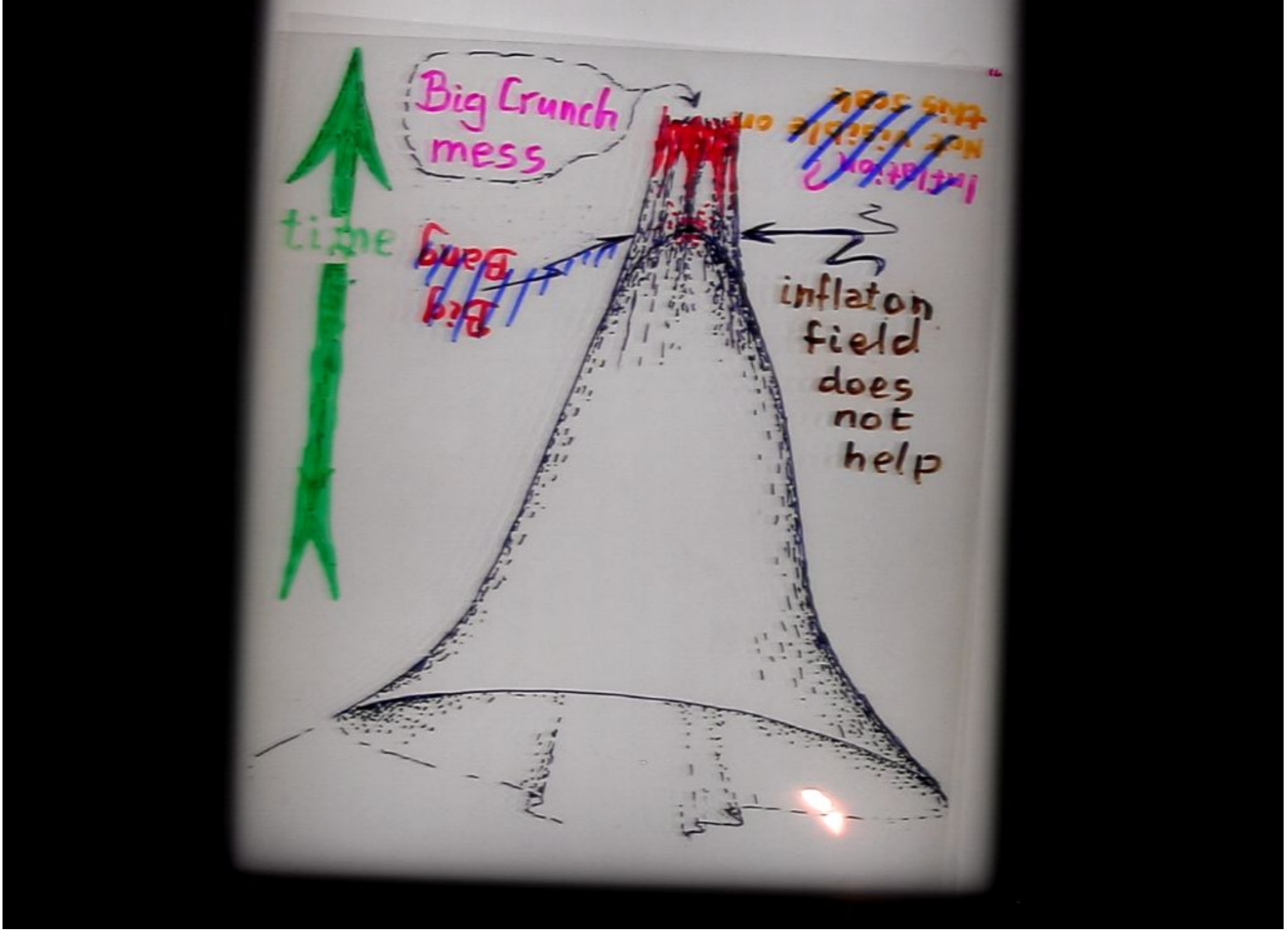
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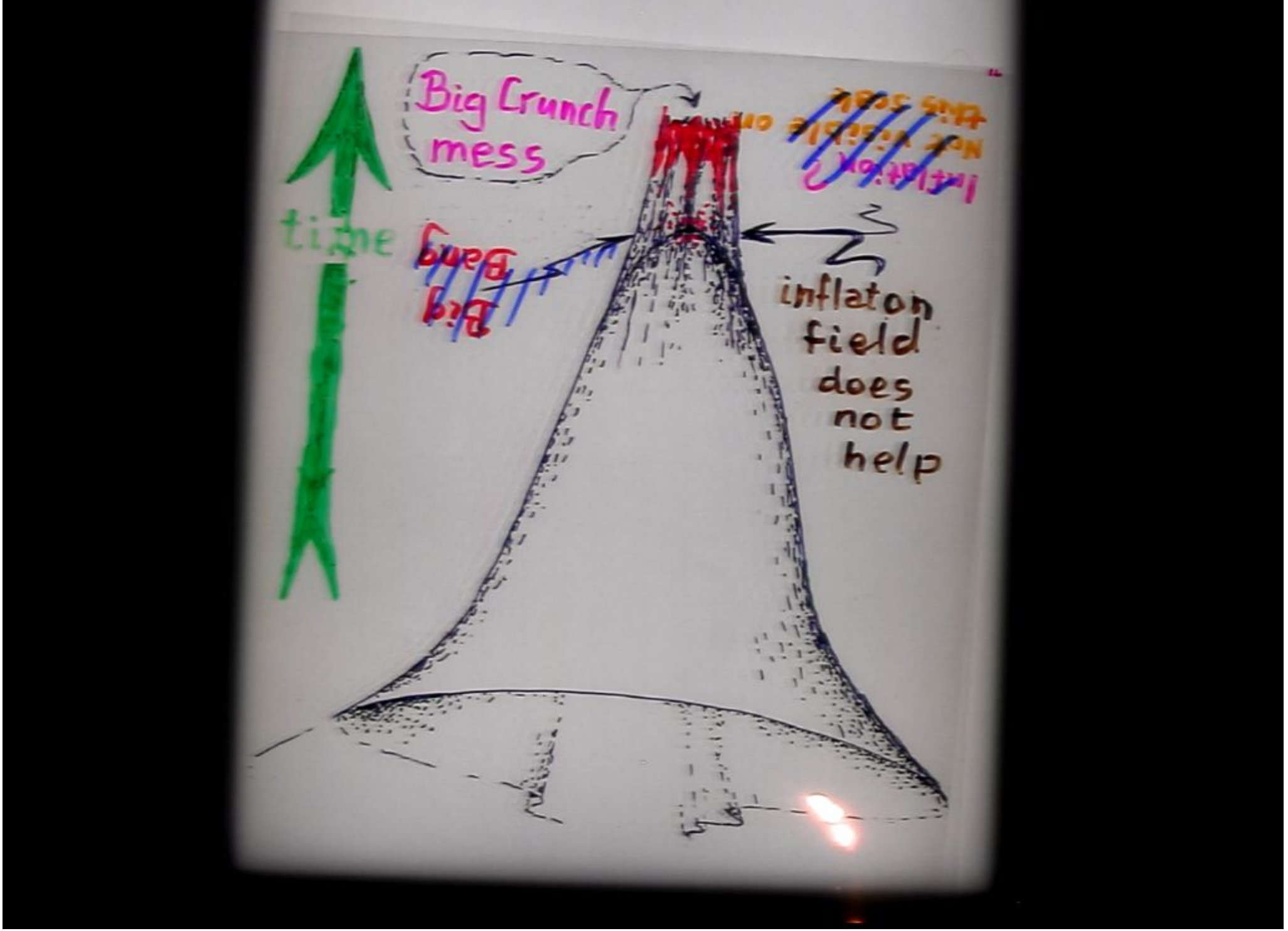
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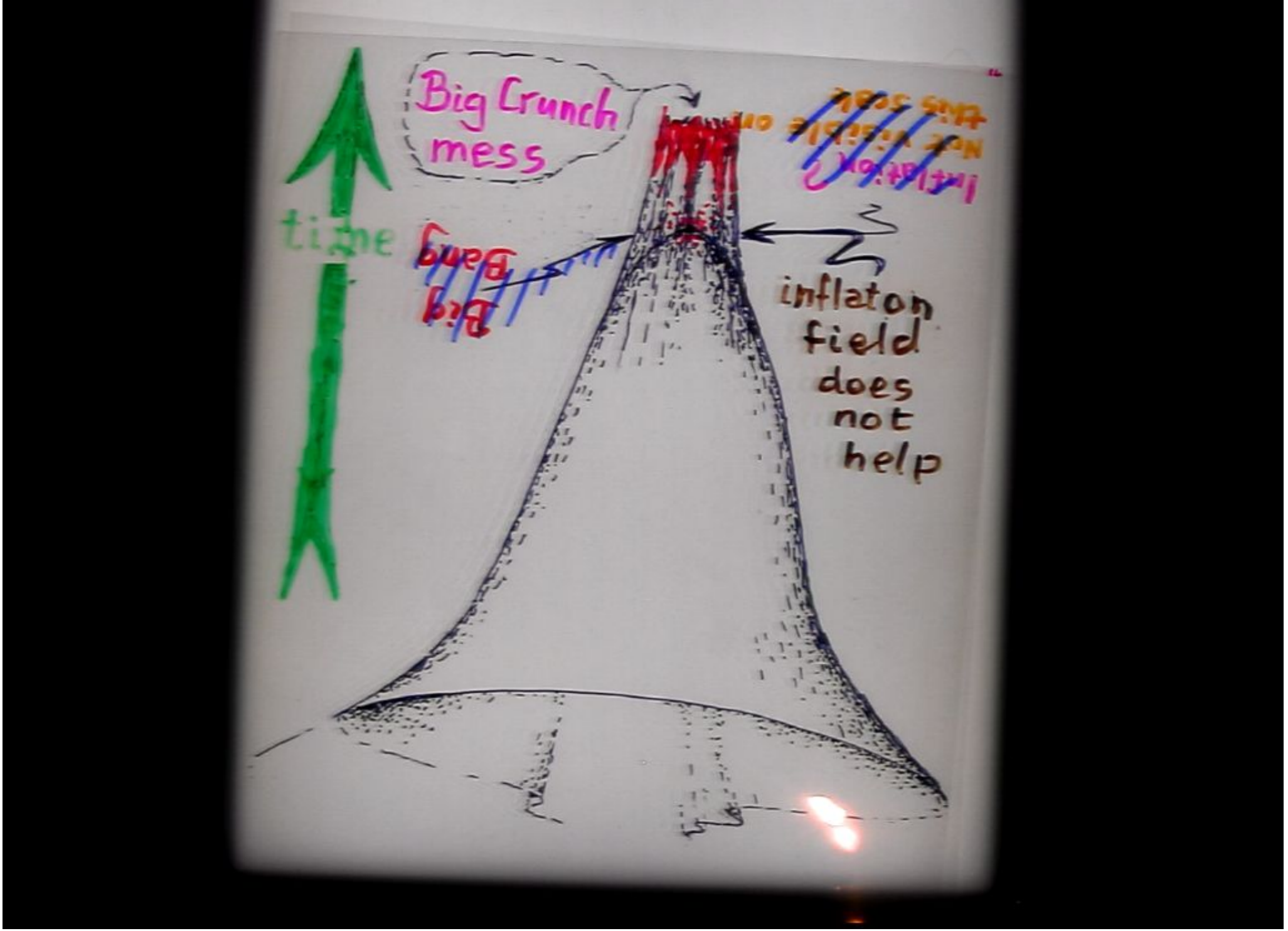
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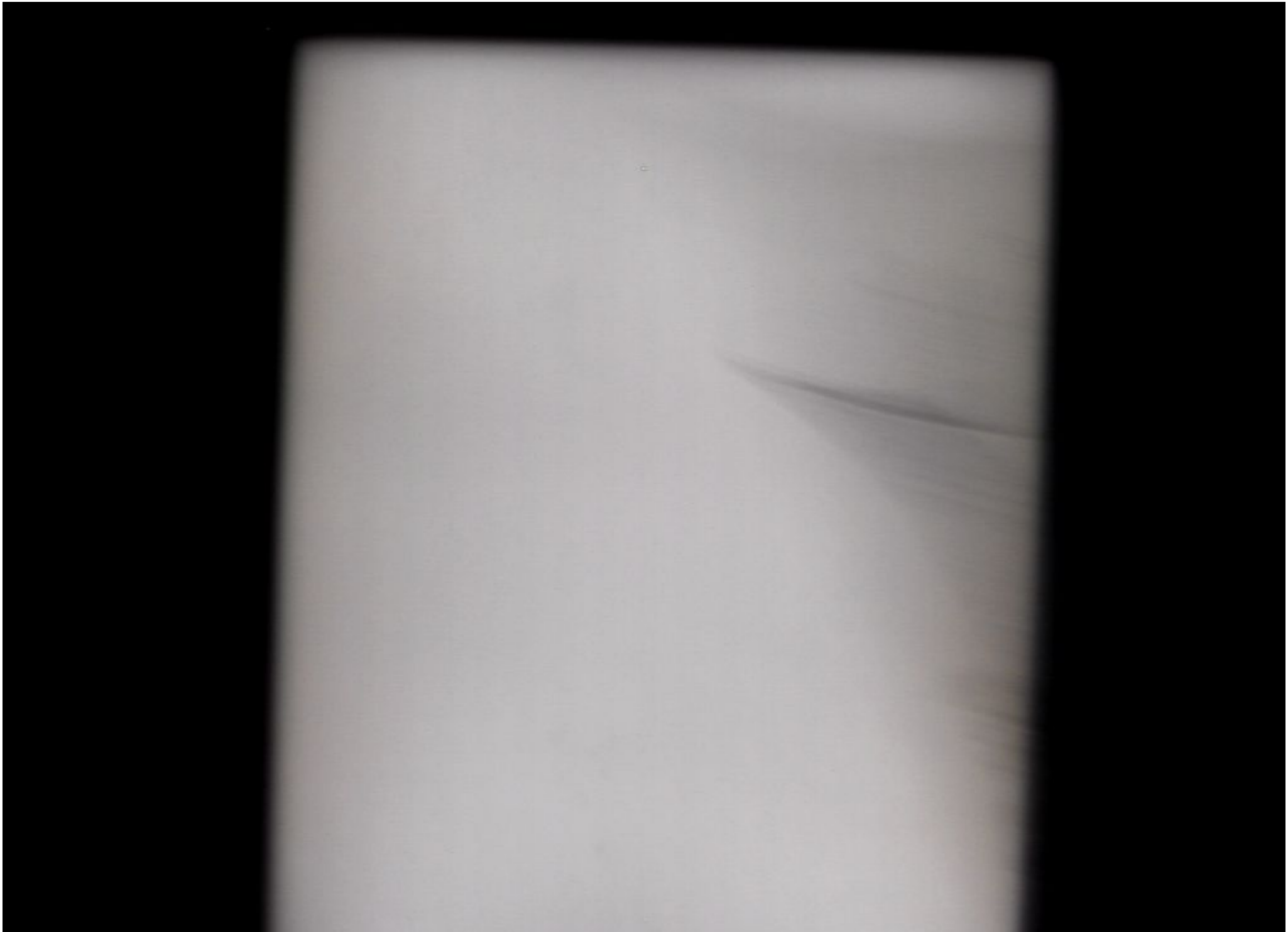

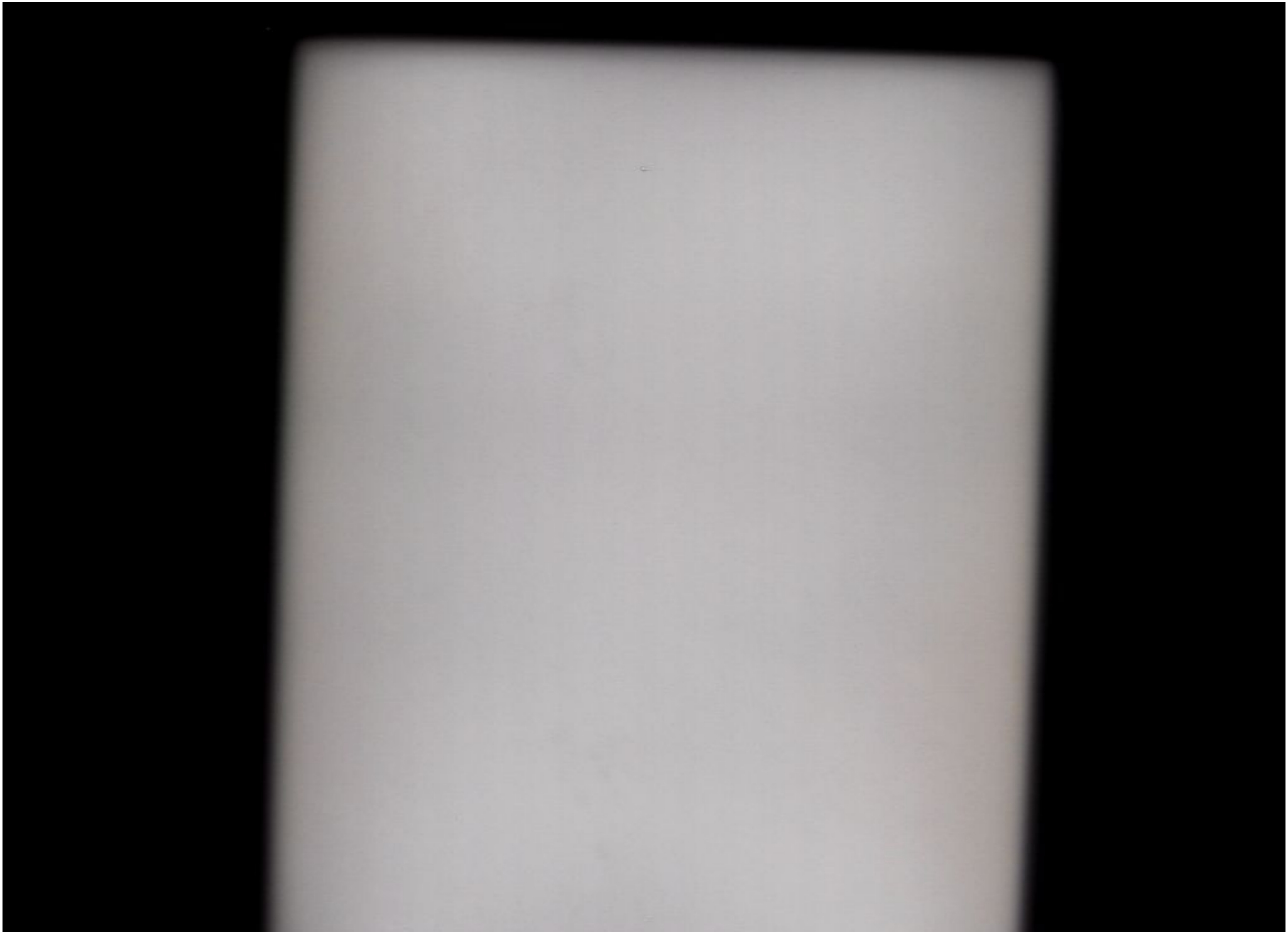

Fundamental problem raised by the 2nd law of thermodynamics & the nature of the Big Bang:

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

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

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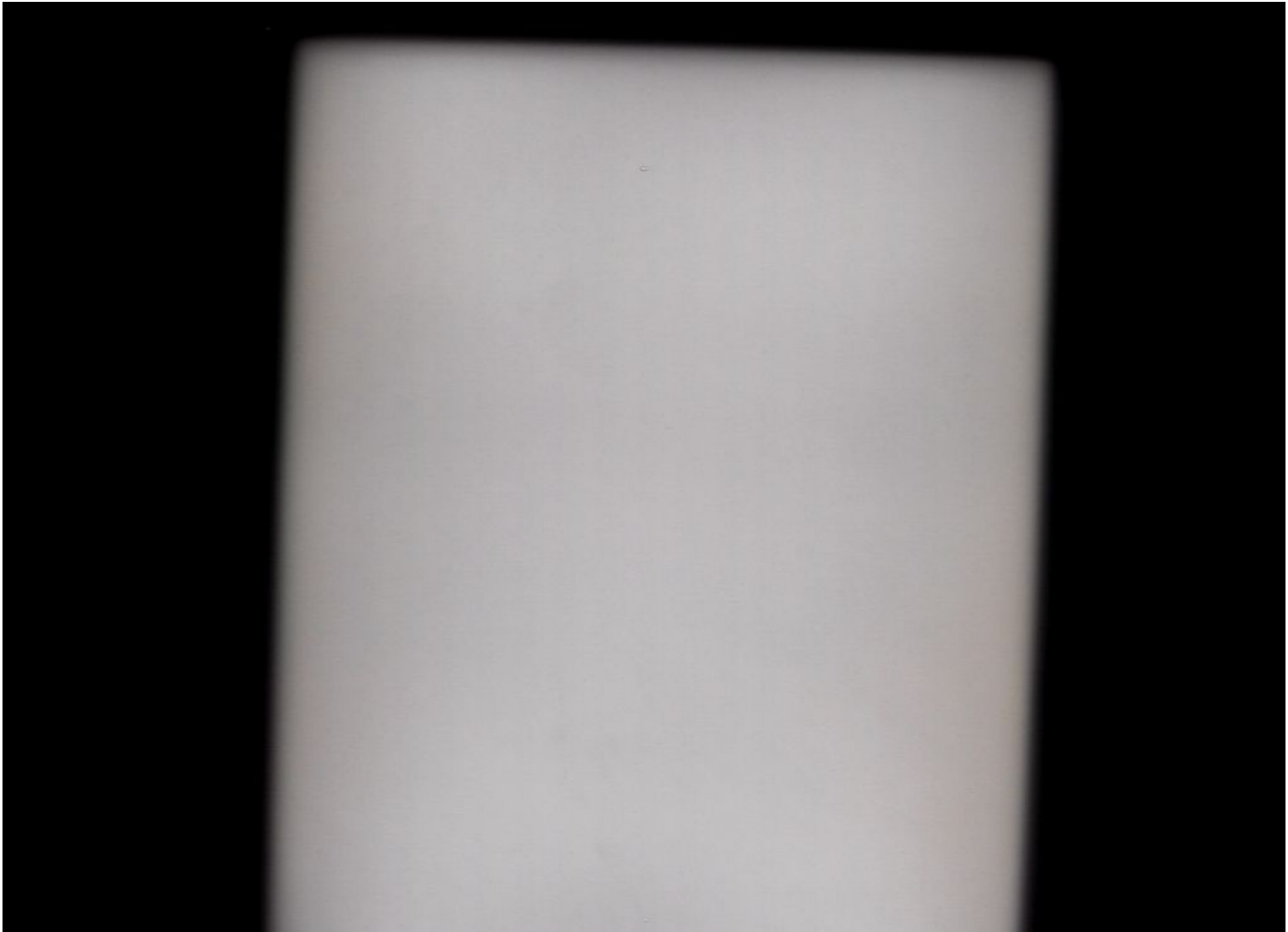
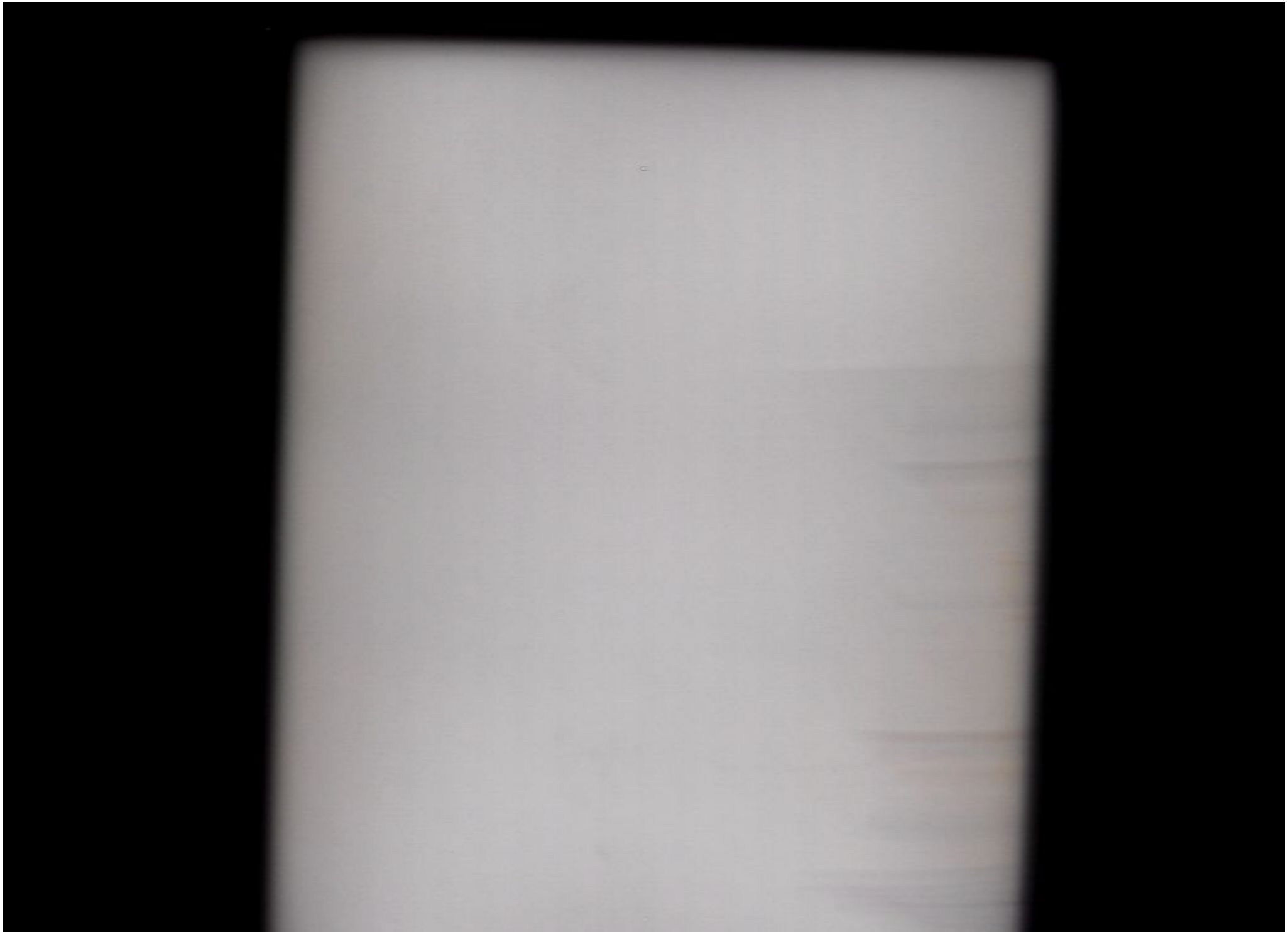
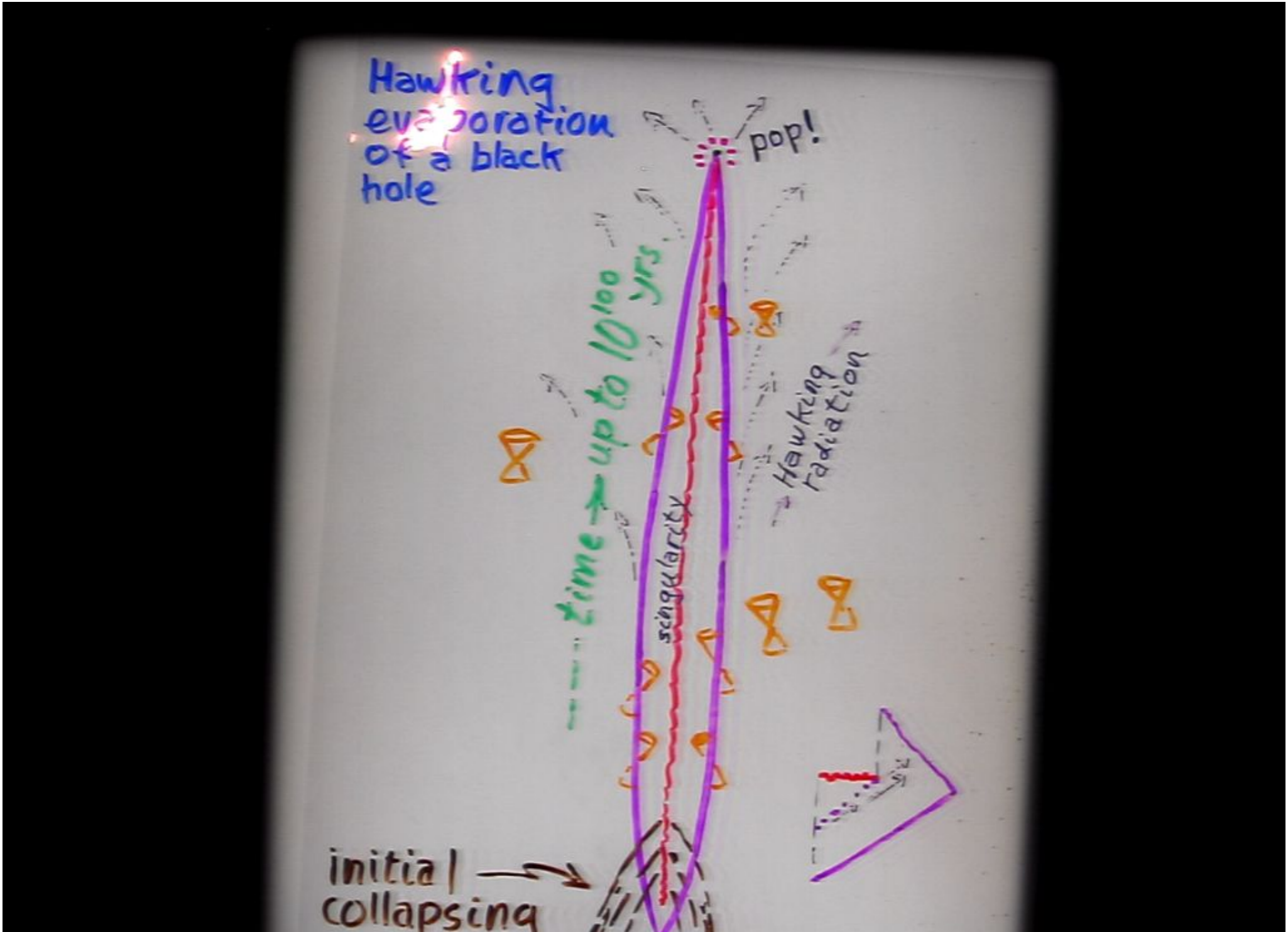
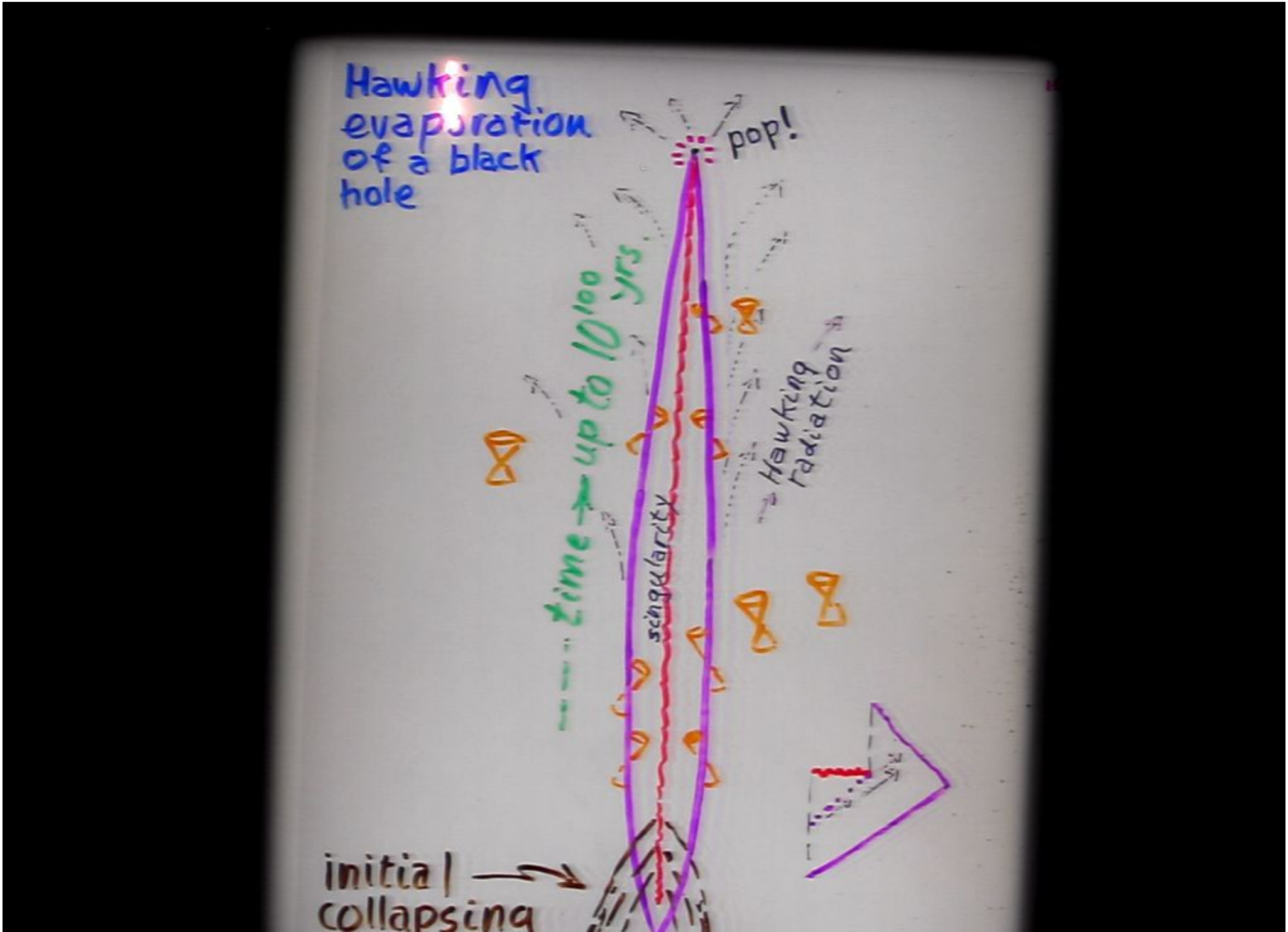







Hawking evaporation of a black hole
pop!
time → up to 10^{100} yrs
singularity
Hawking radiation
initial collapsing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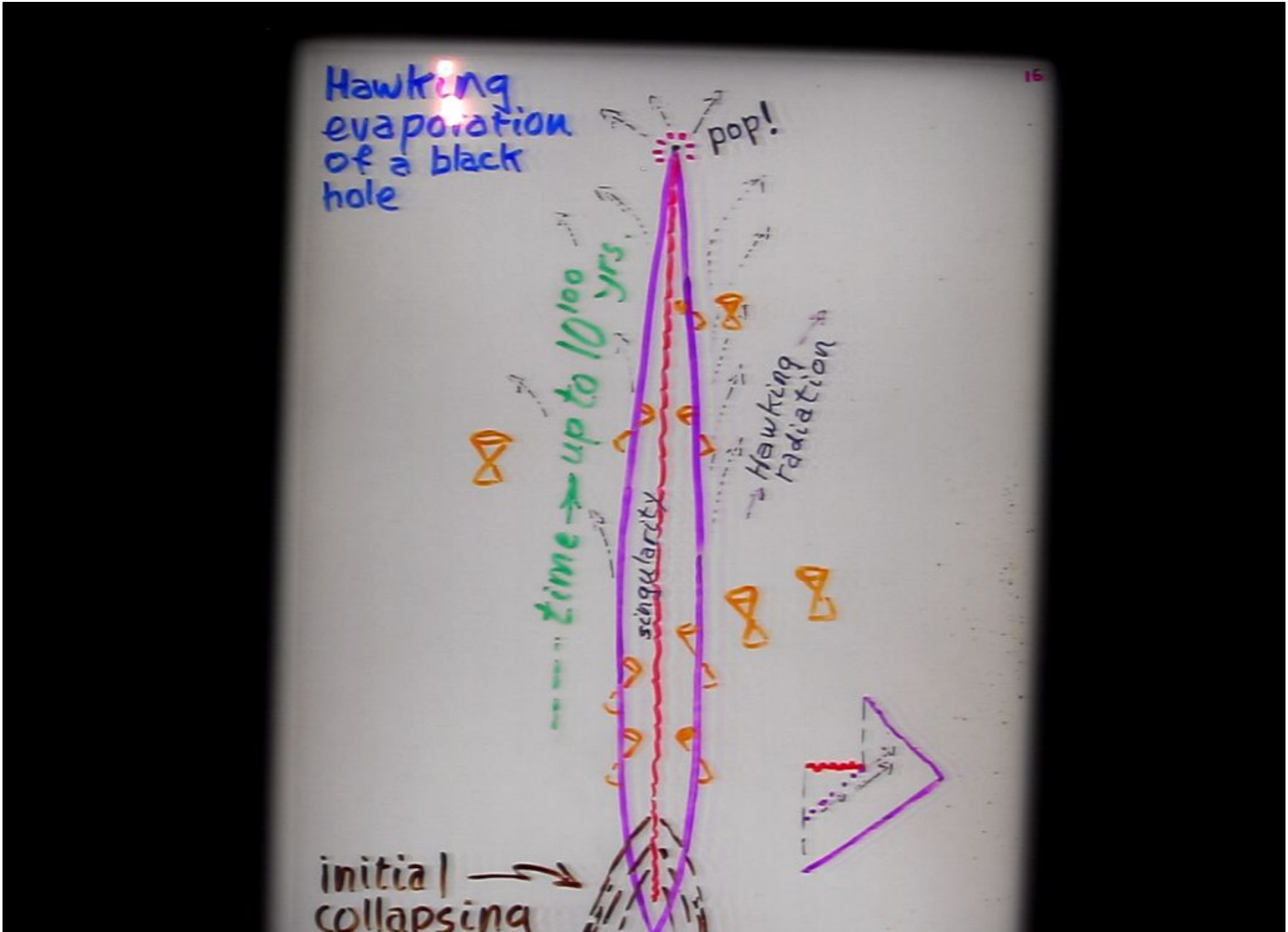
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16
pop!
time → up to 10^{100} yrs
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Hawking radiation
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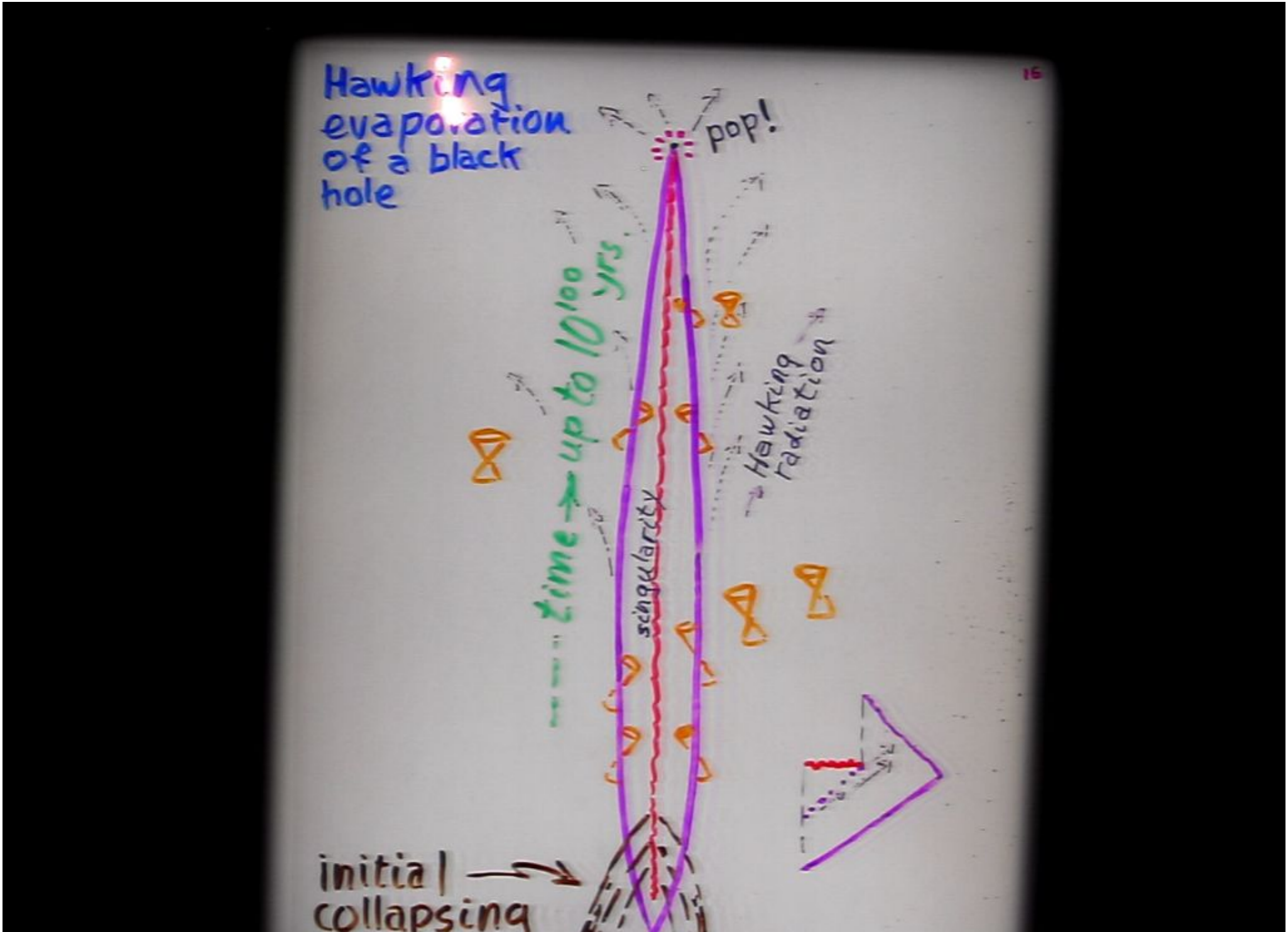
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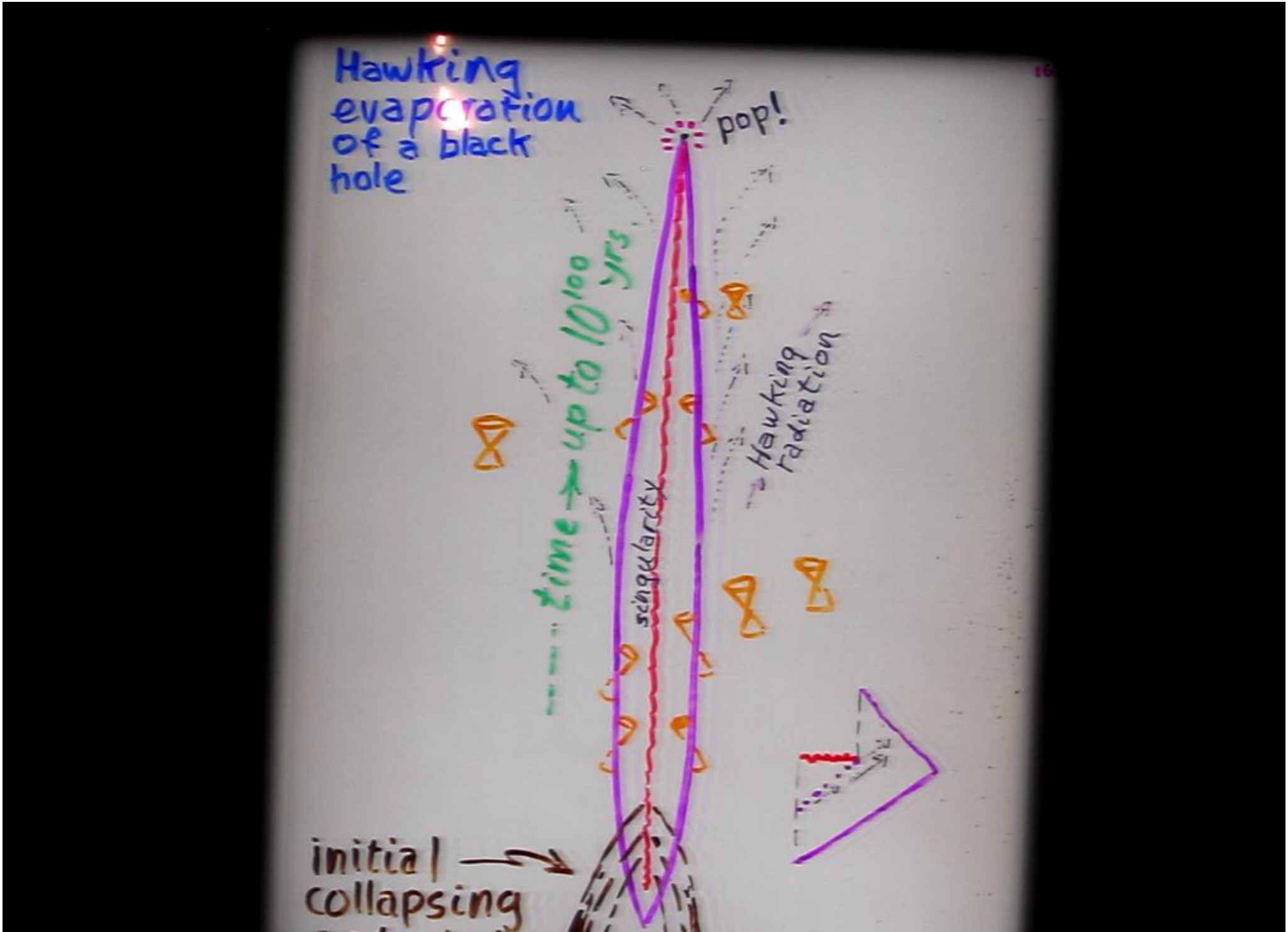
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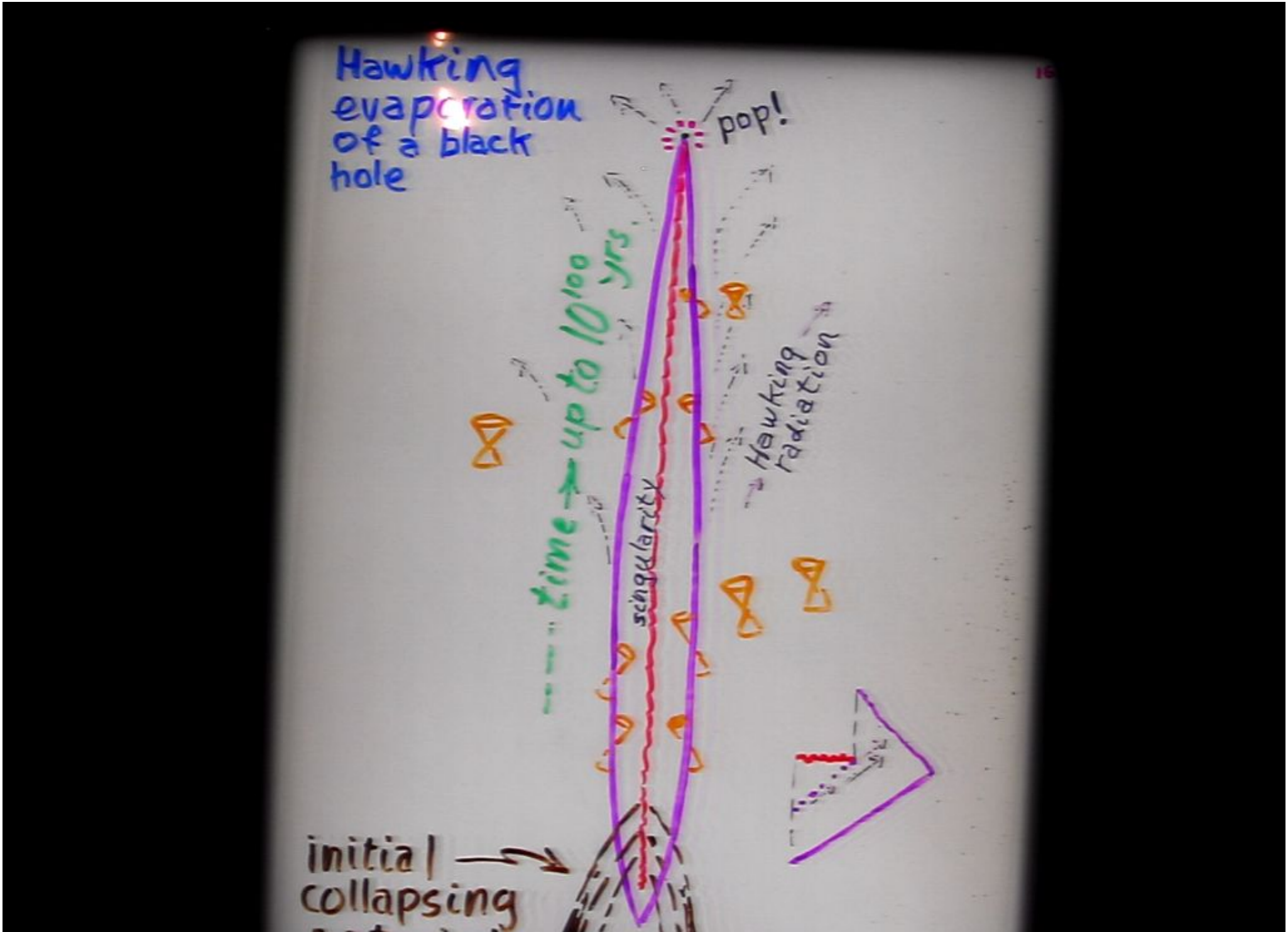
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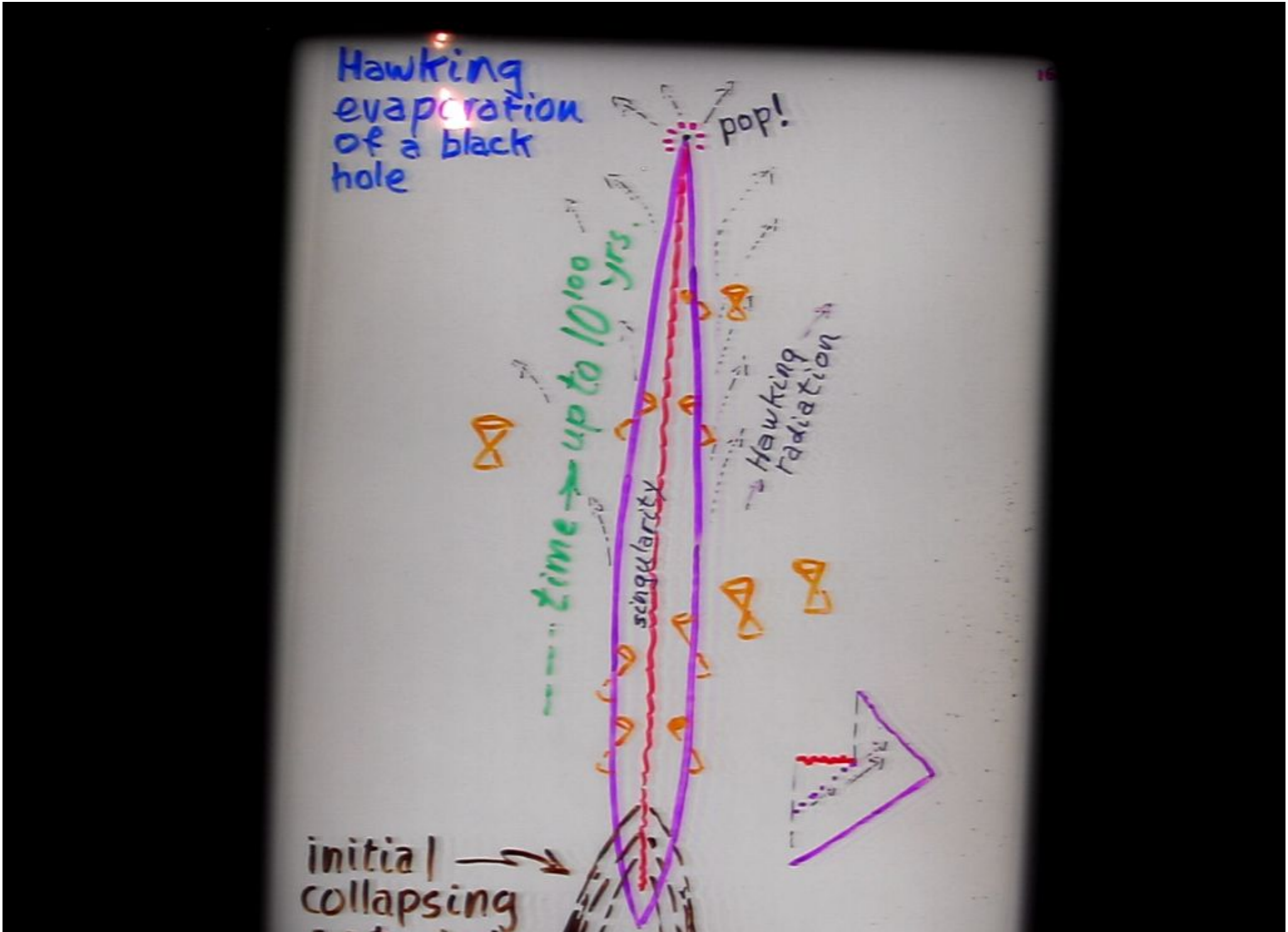
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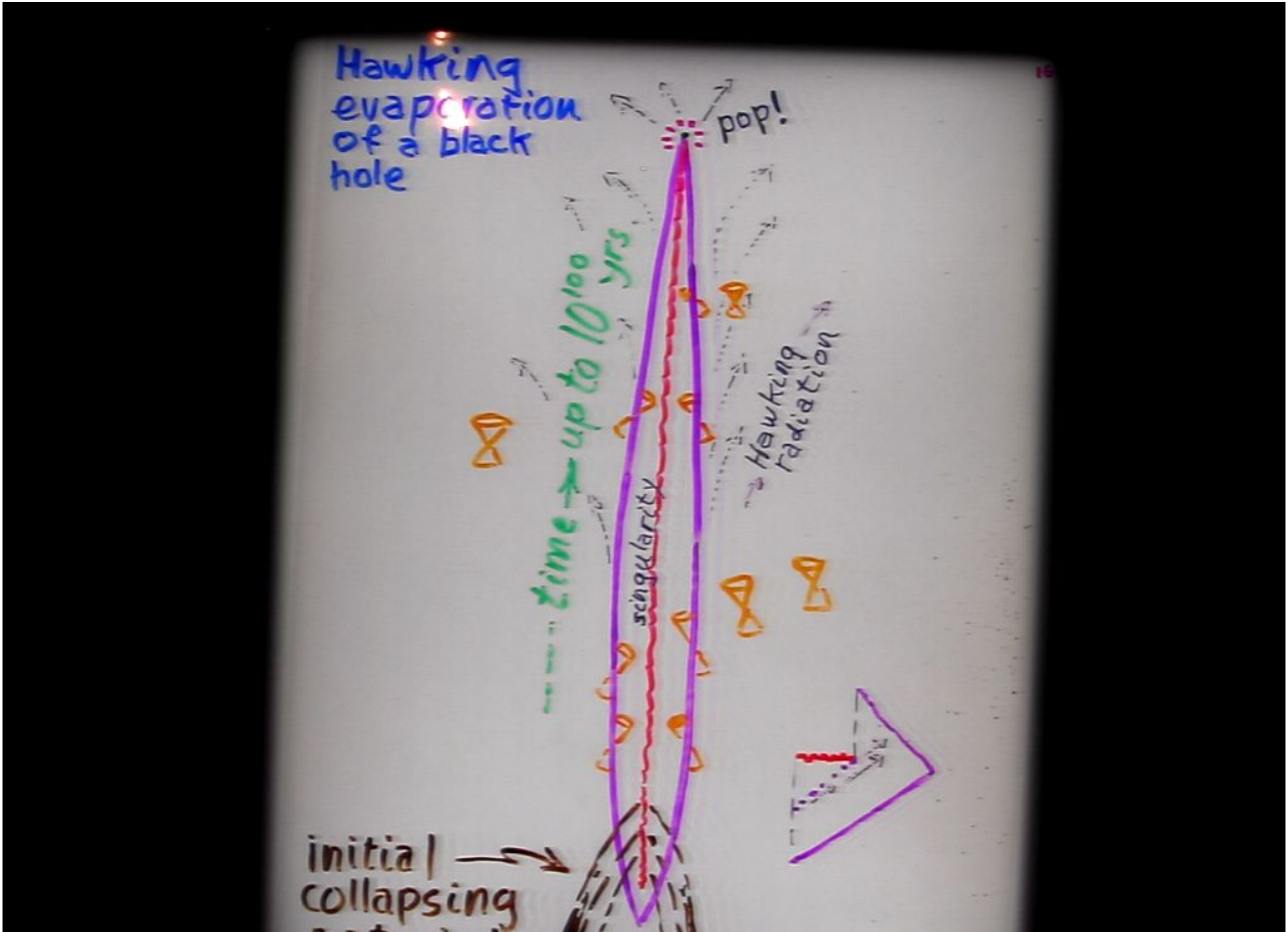
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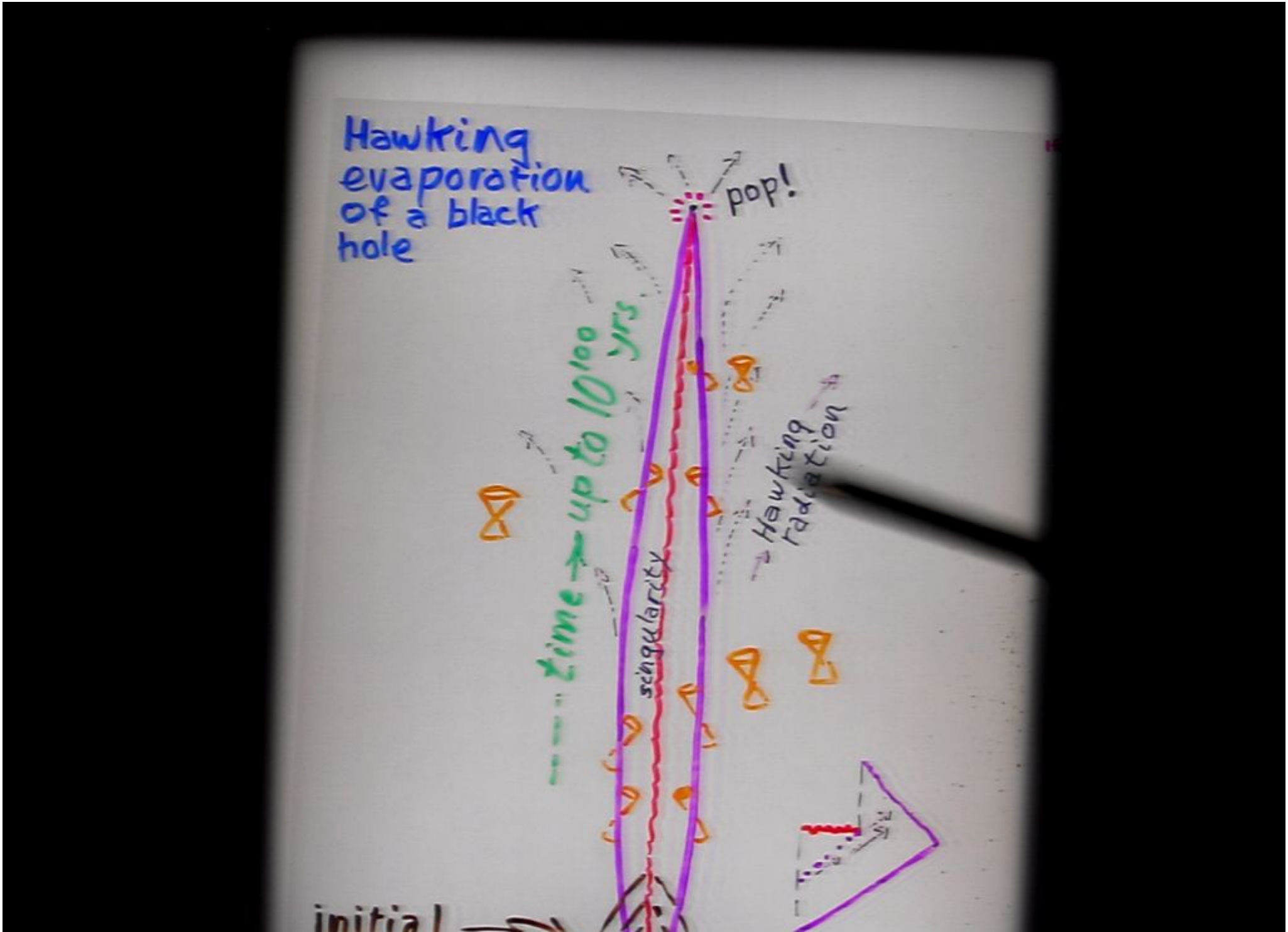
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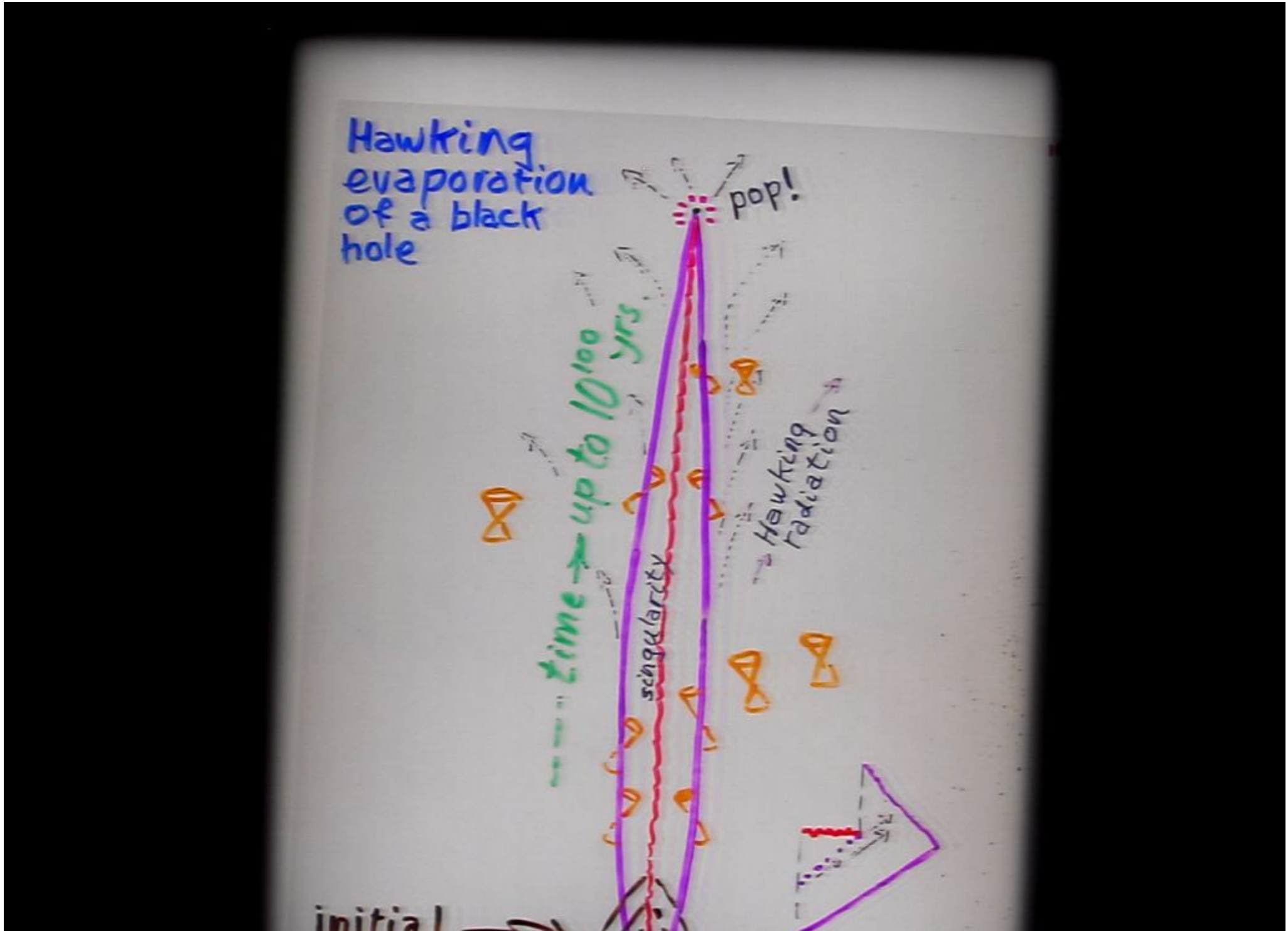
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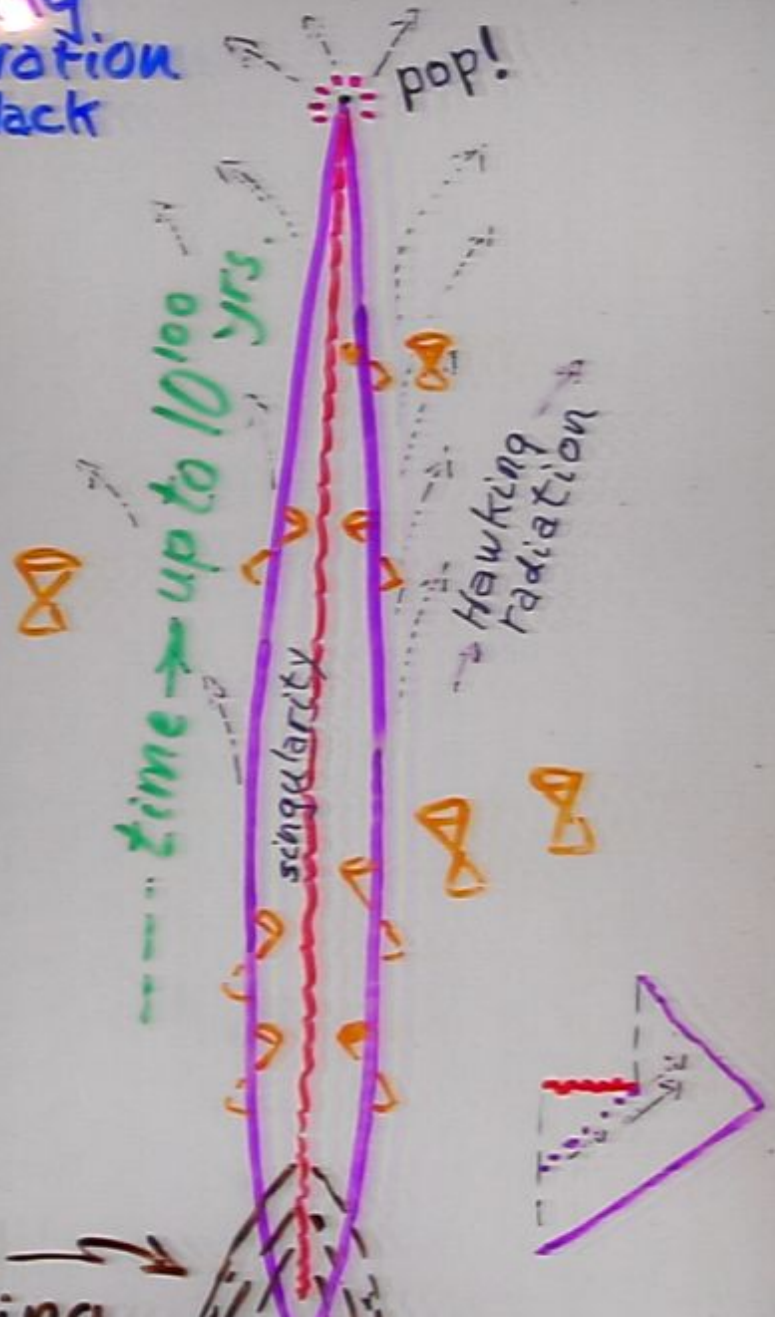
Hawking evaporation of a black hole



Hawking
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of a black
hole
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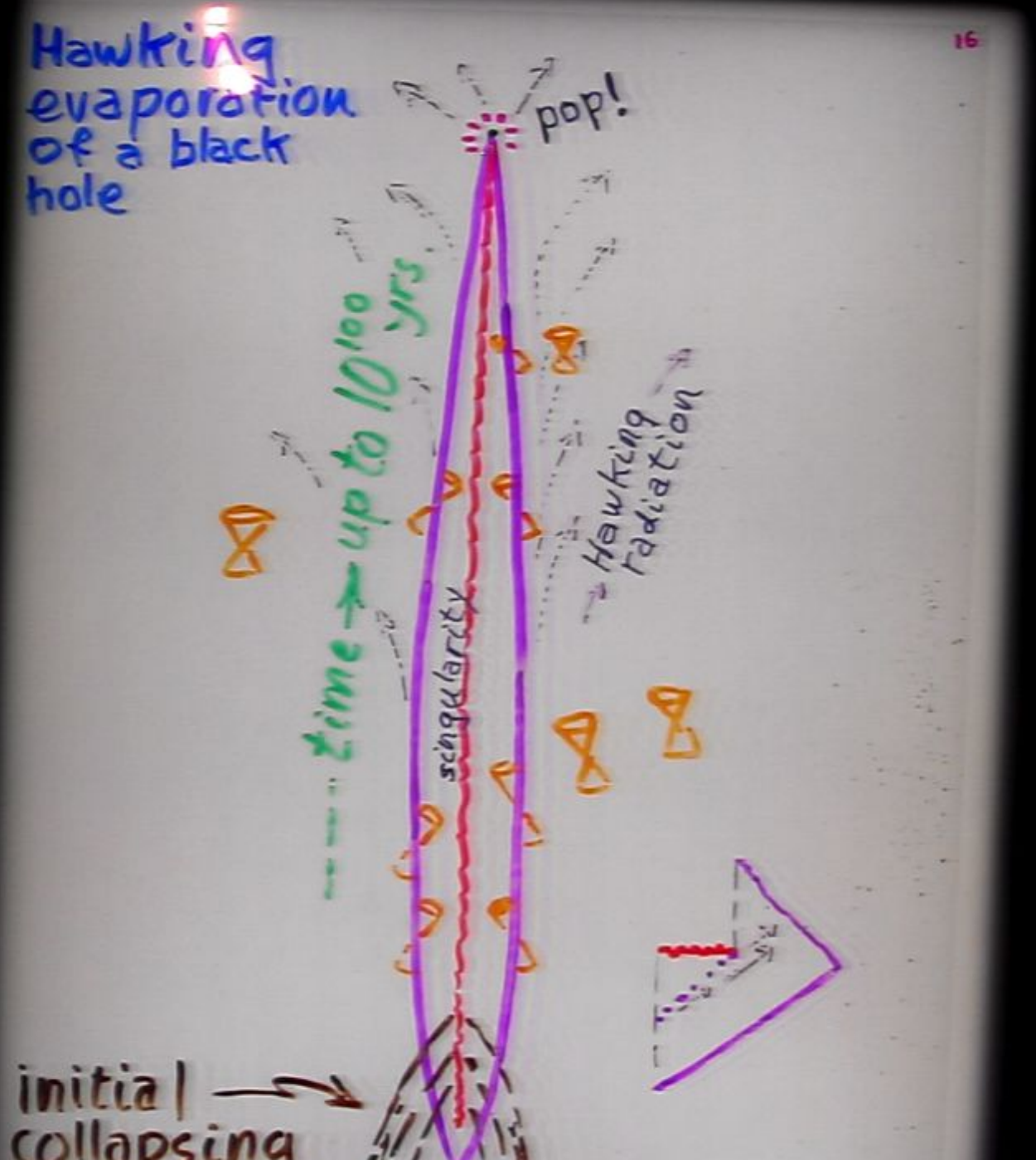
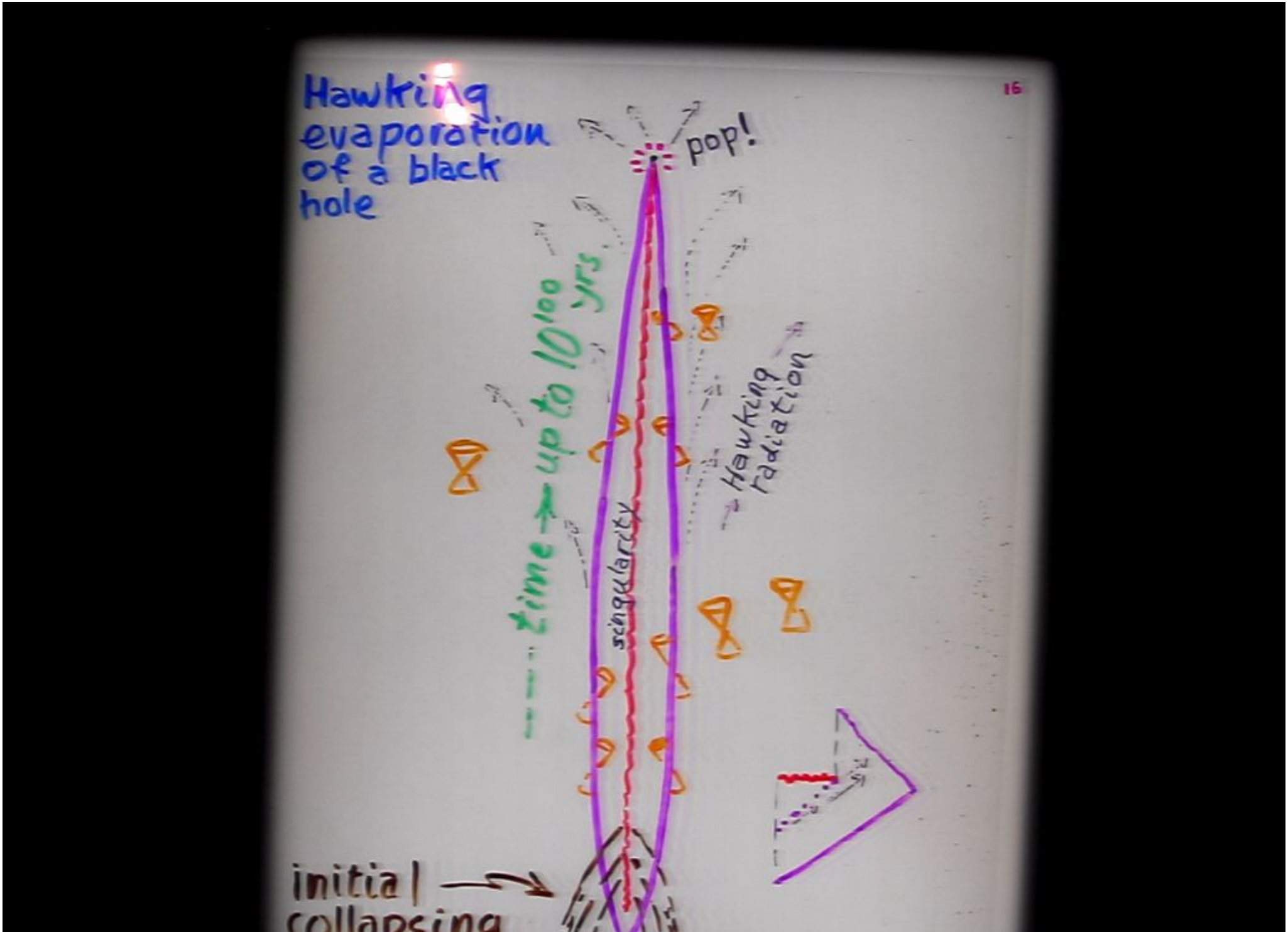
Hawking
radiation
initial
collapse

Hawking evaporation of a black hole

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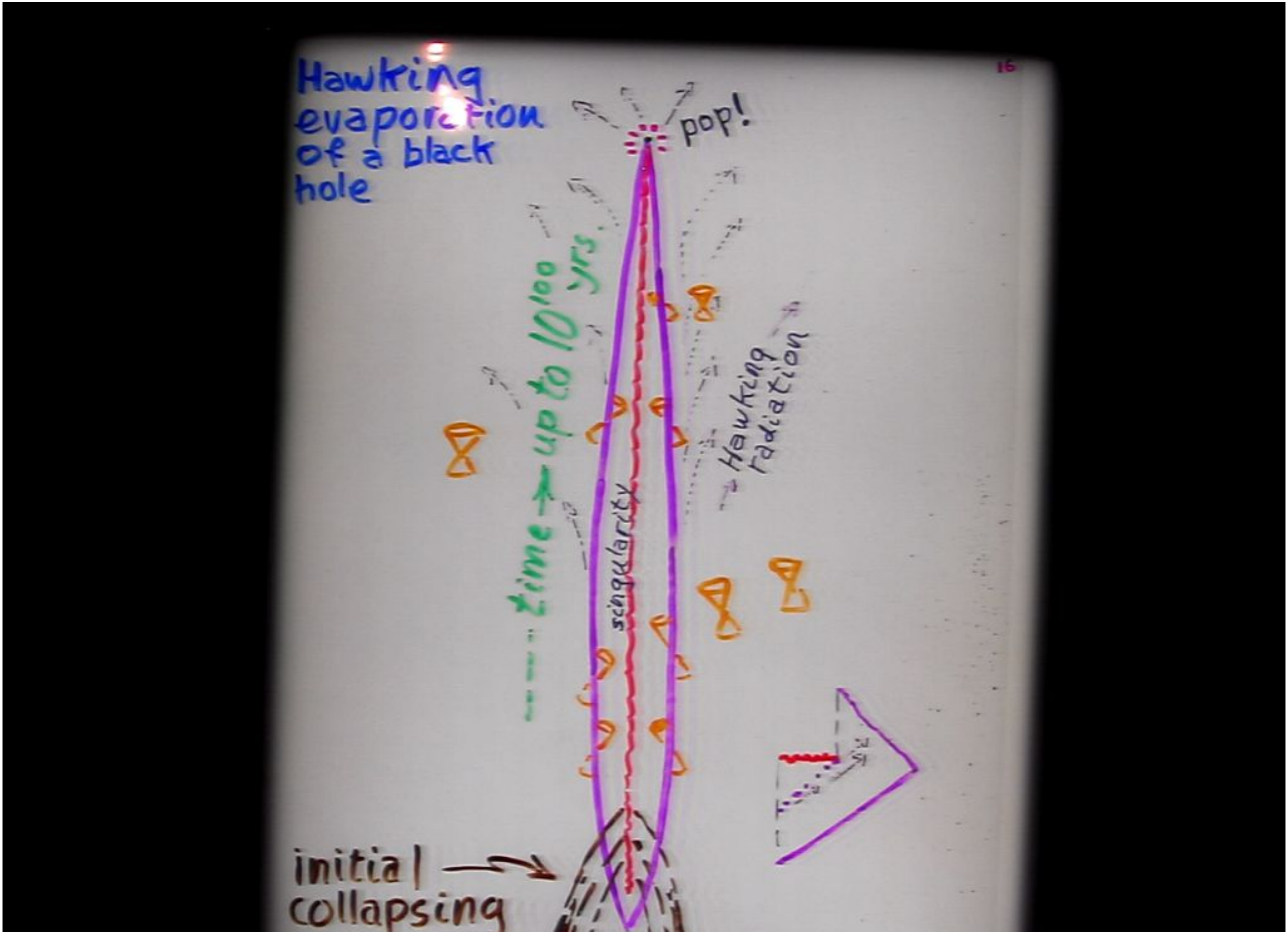
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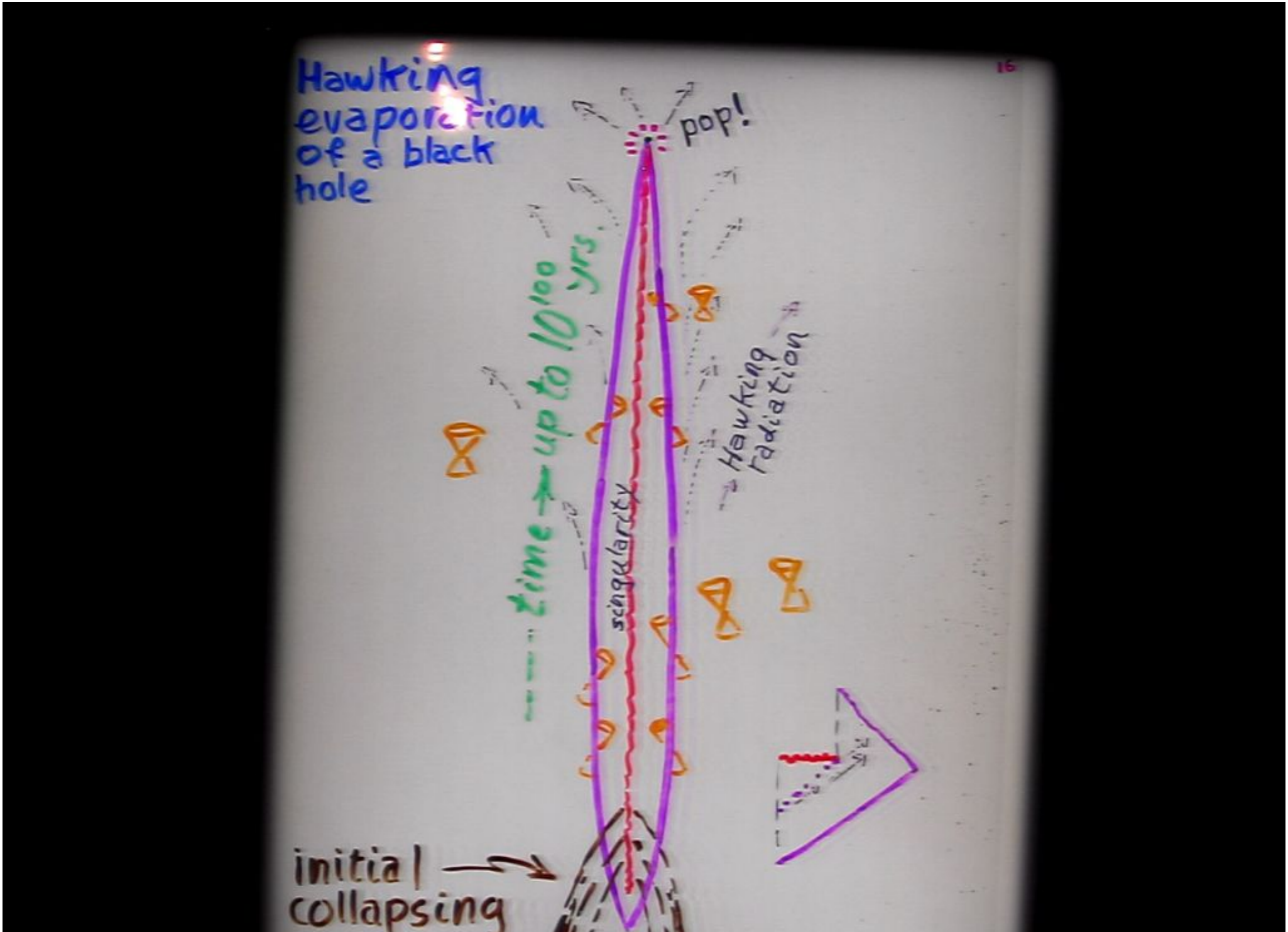
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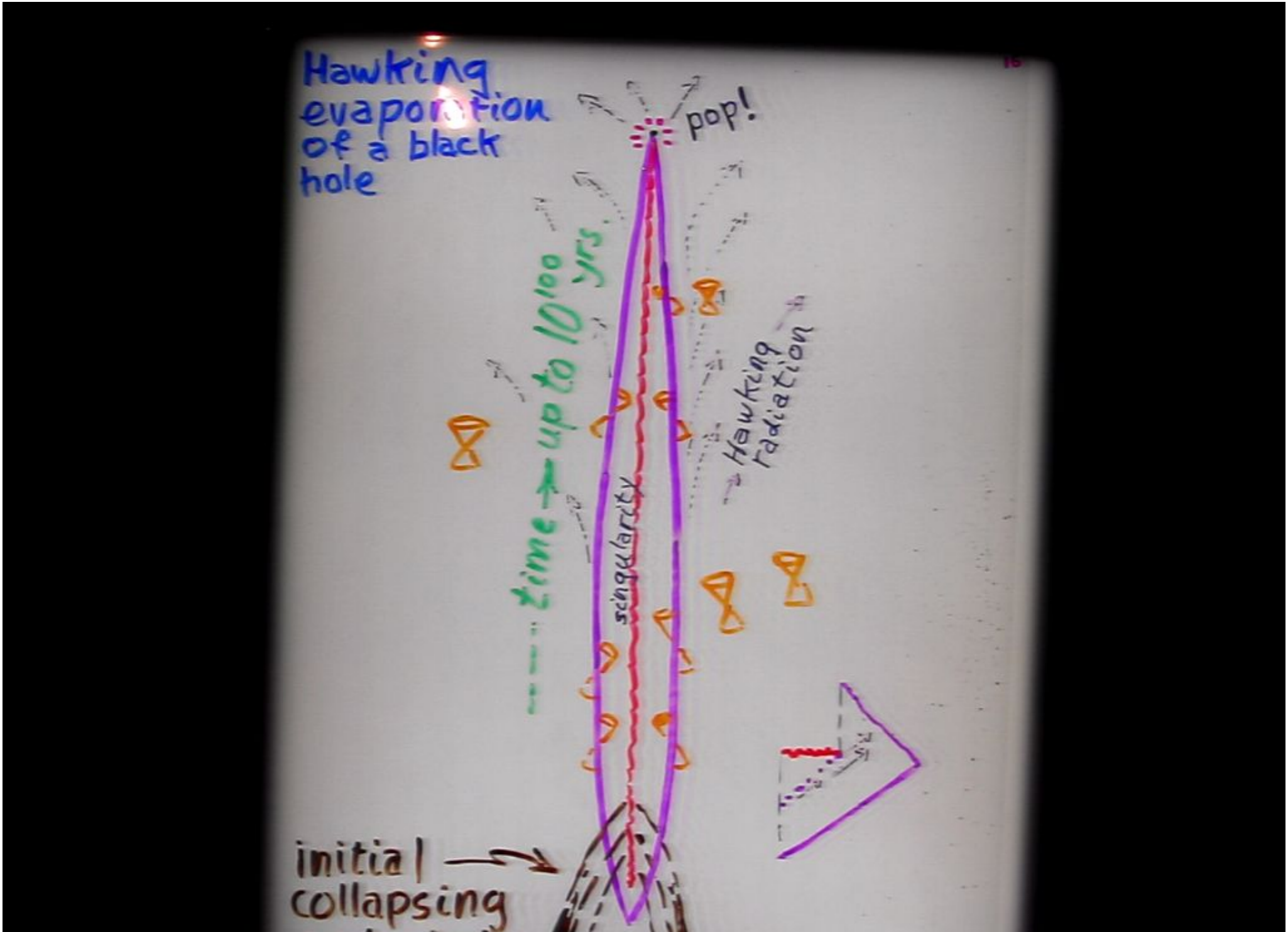
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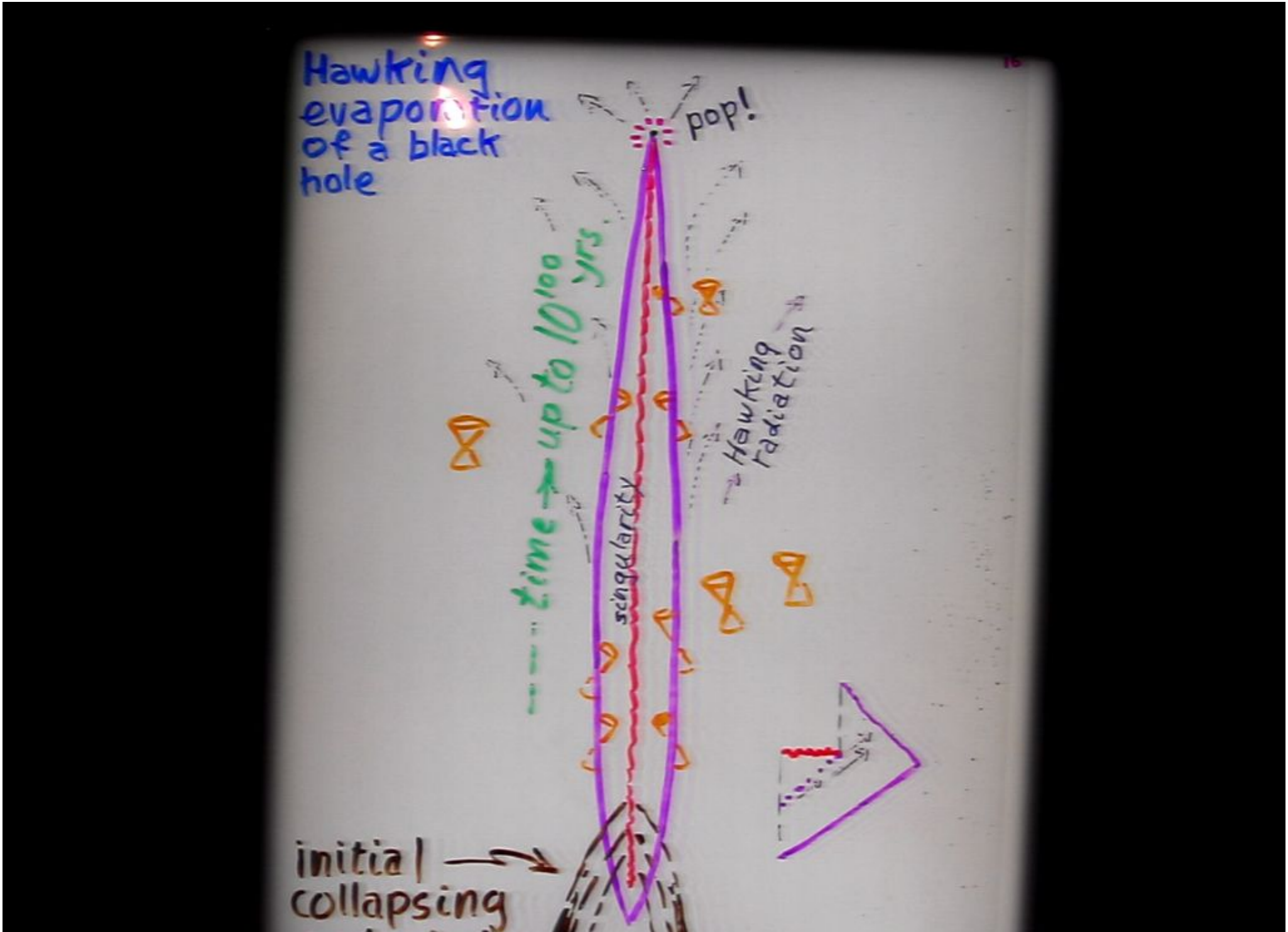
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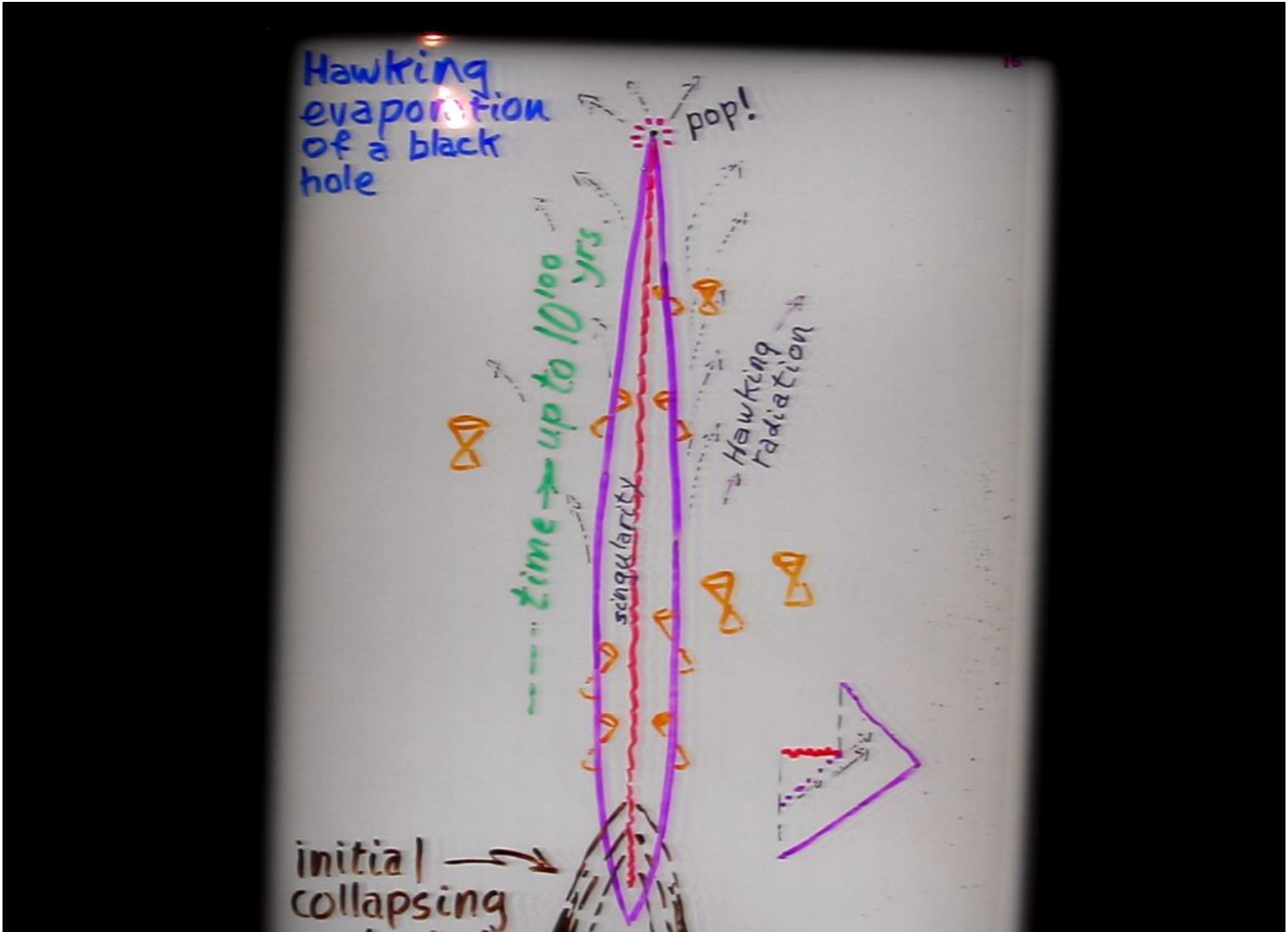
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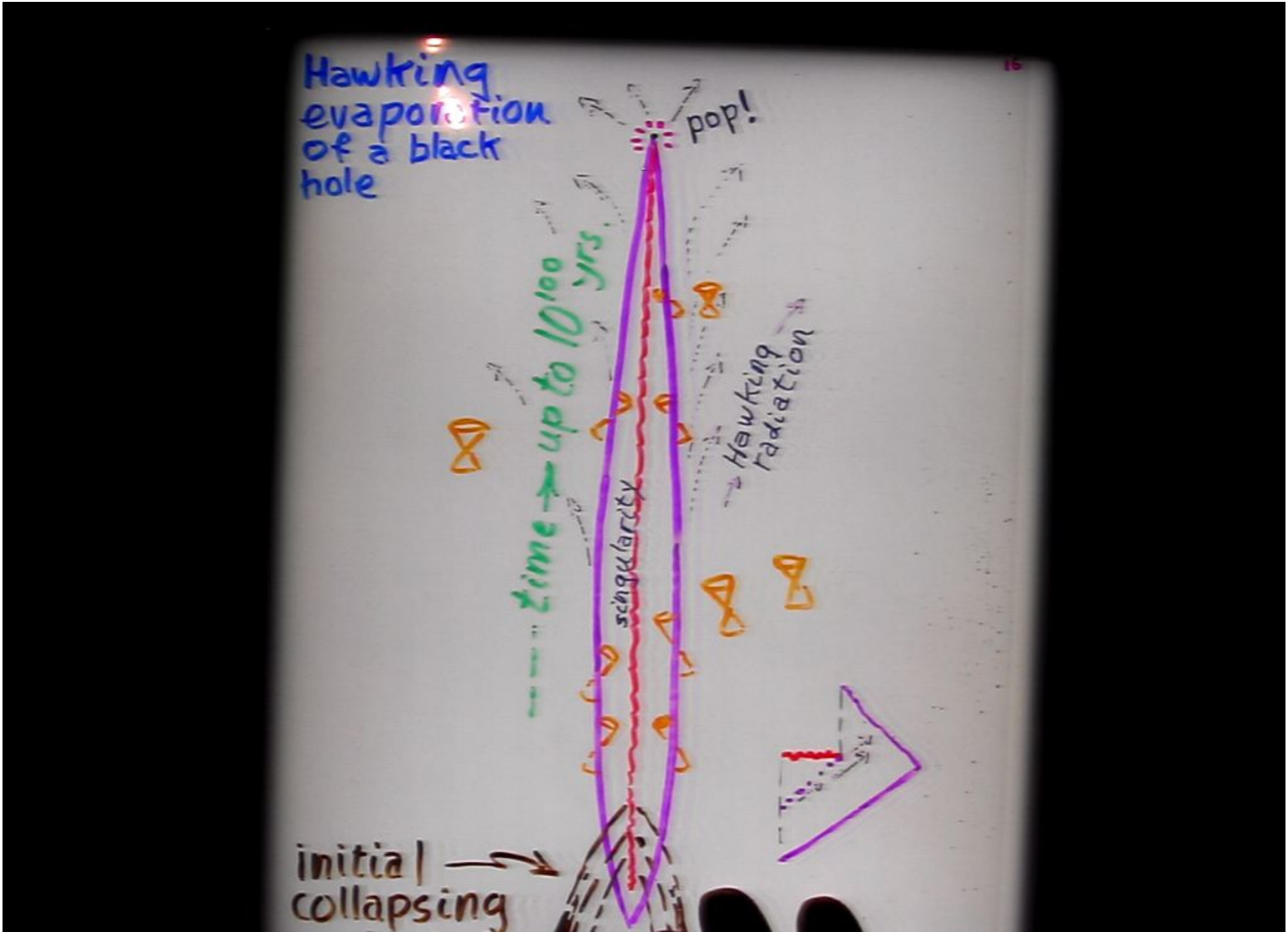
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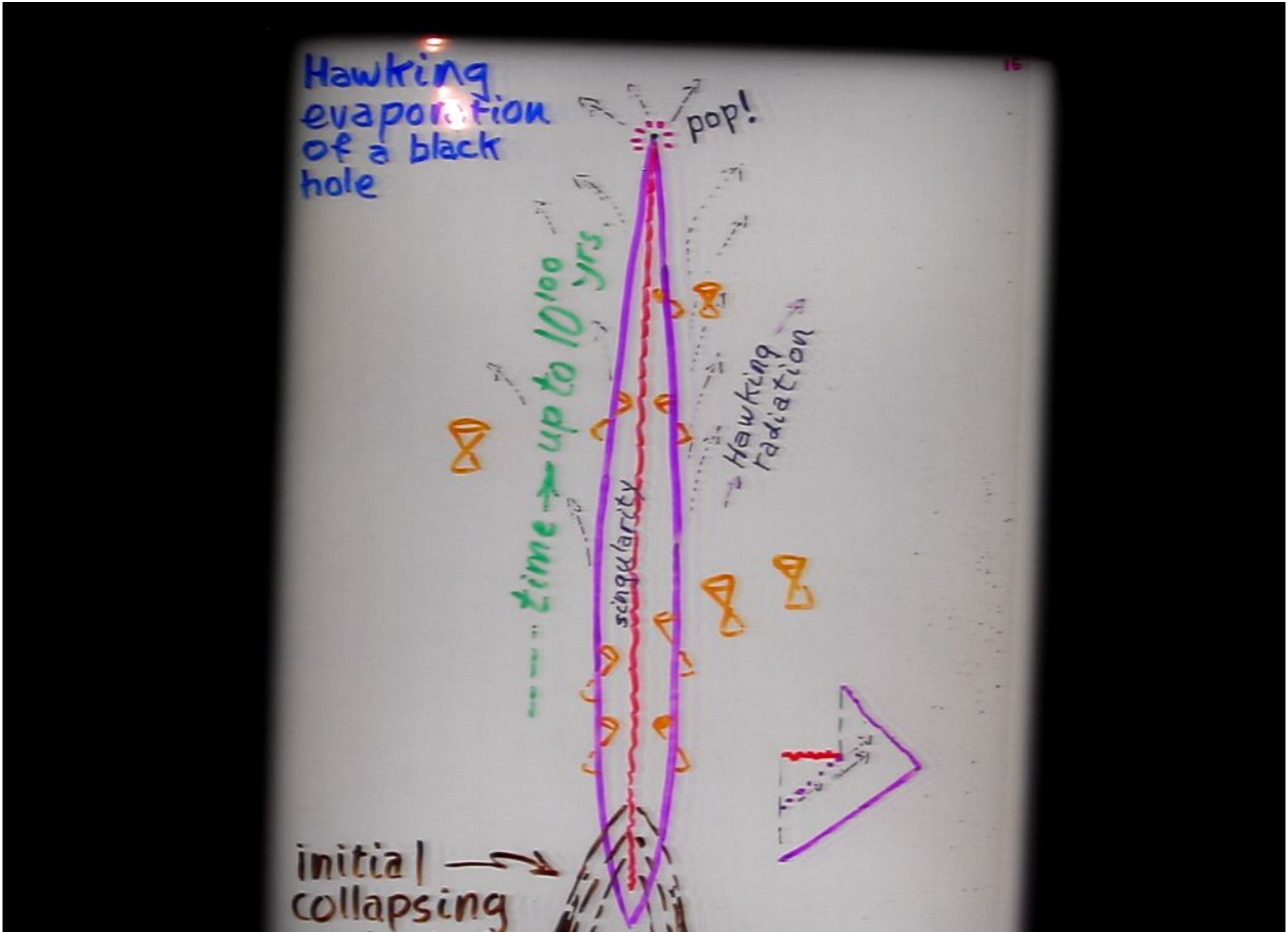
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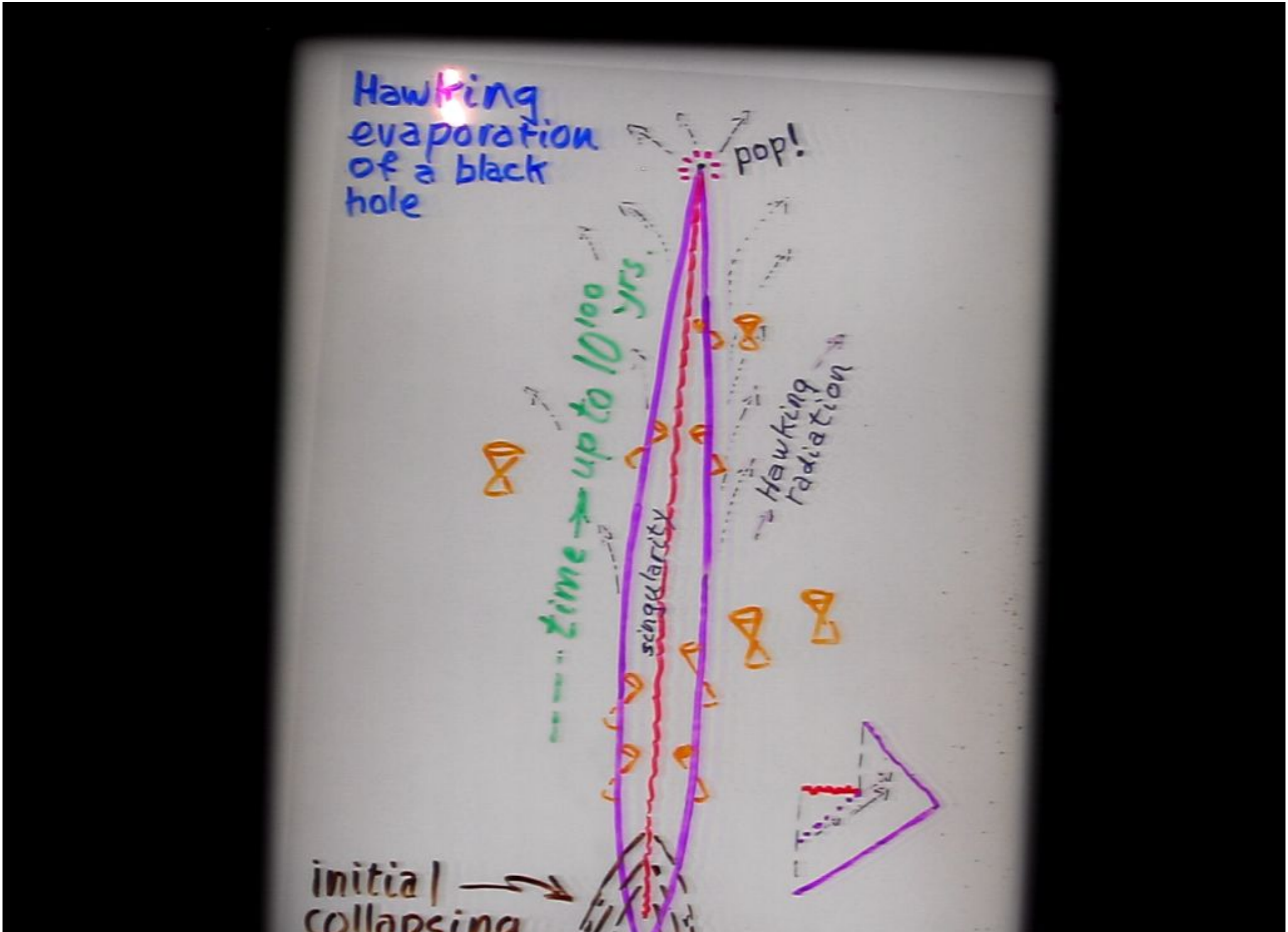
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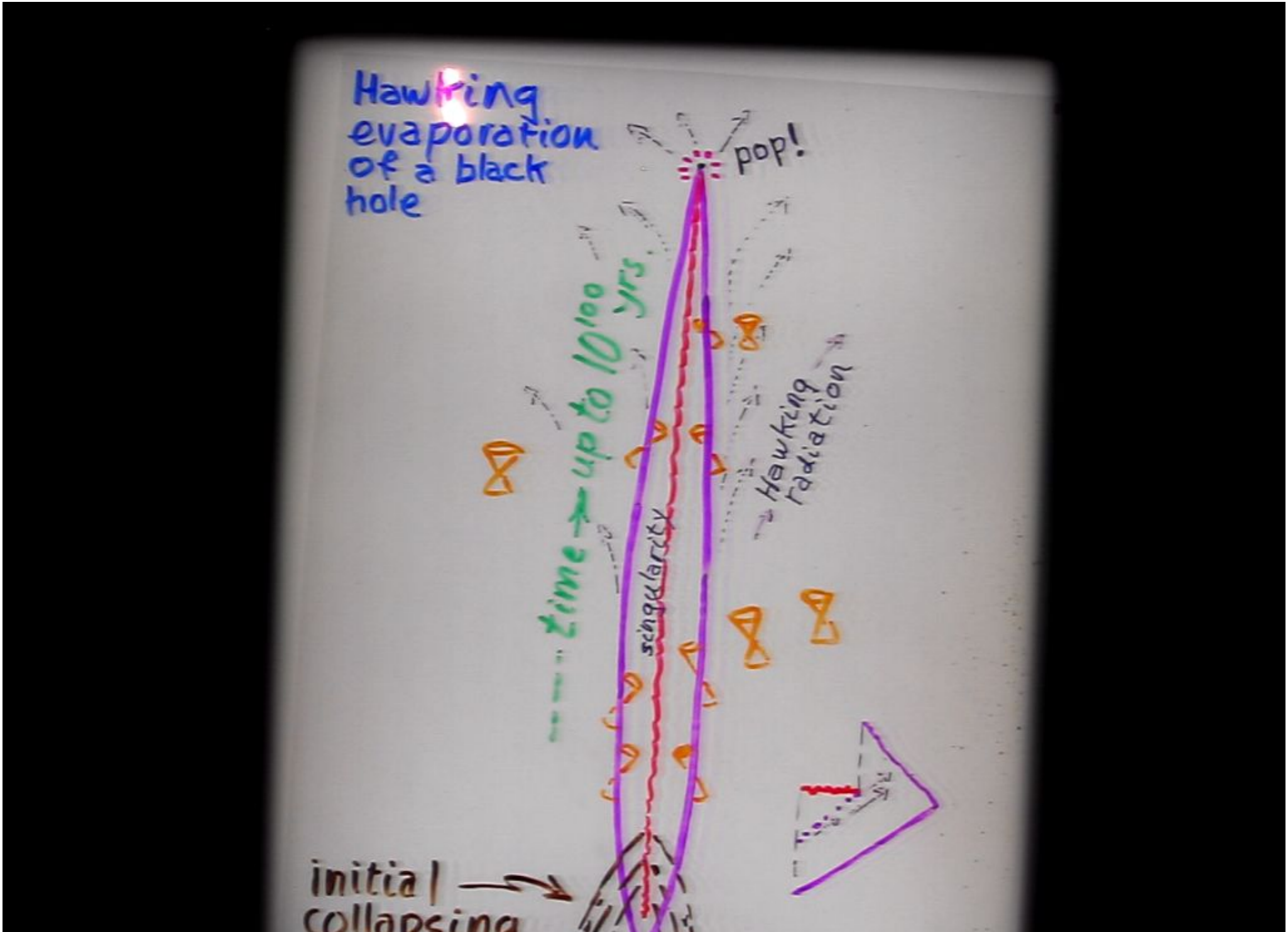
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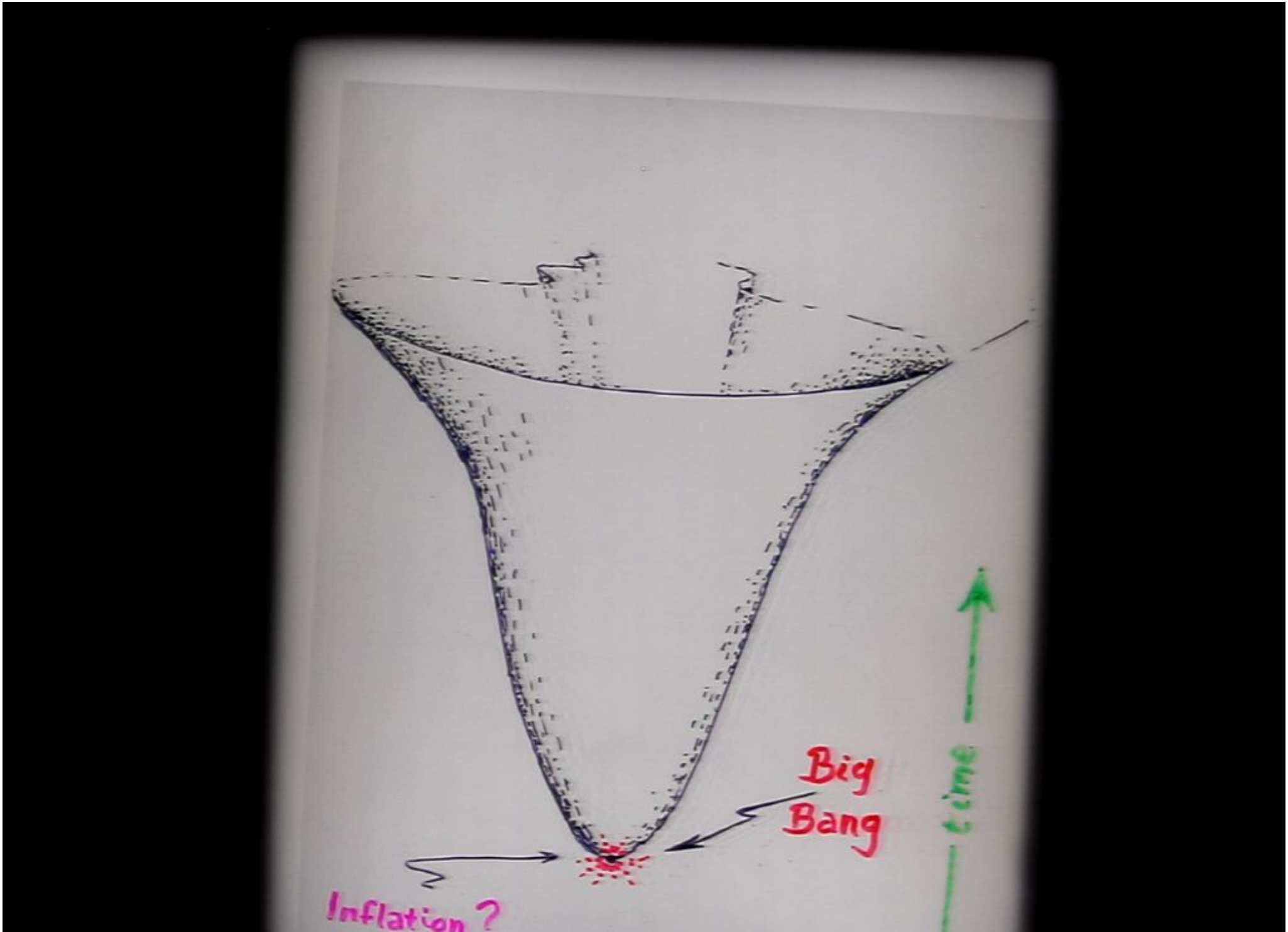
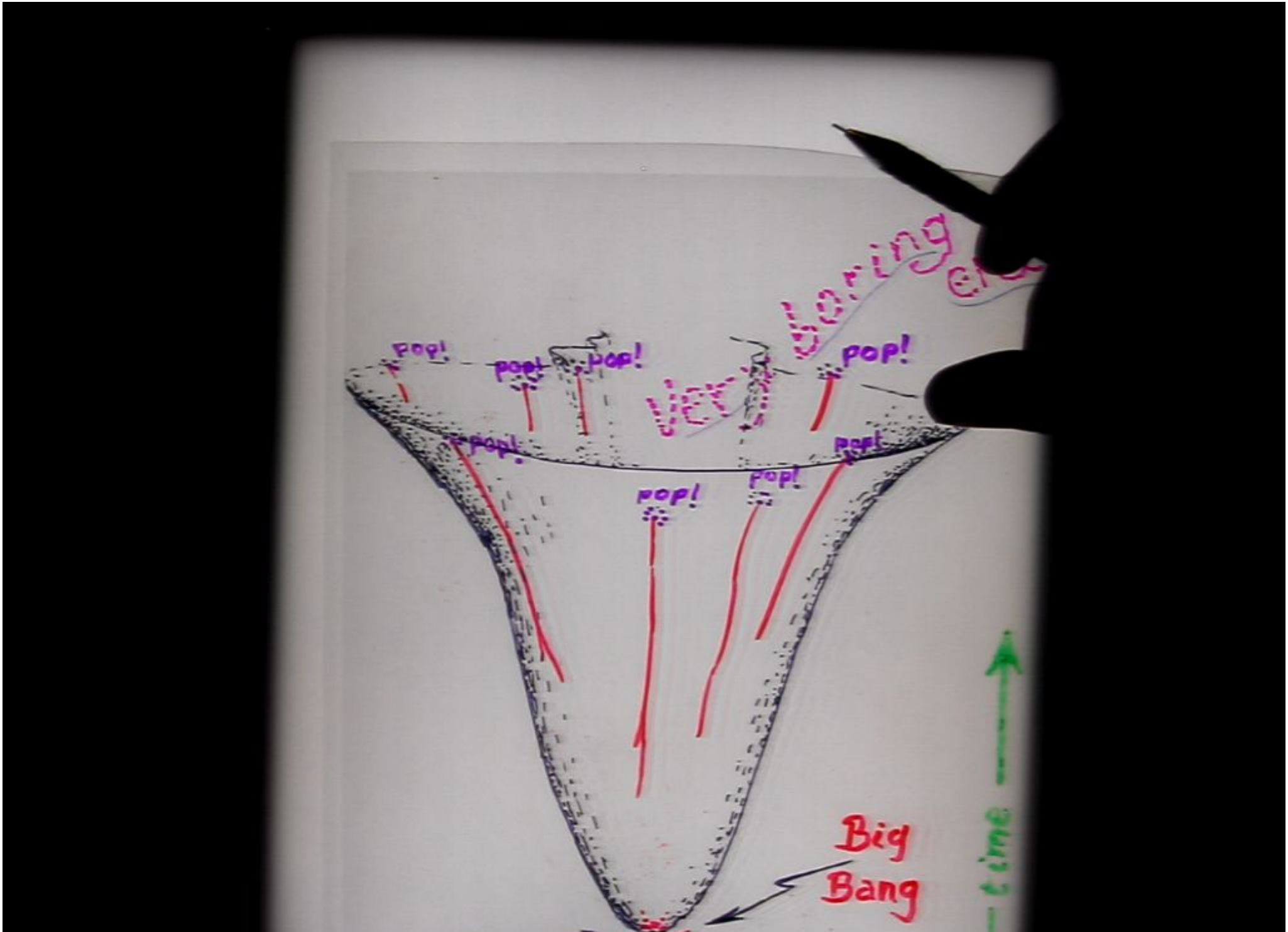

Big
Bang
time
Inflation ?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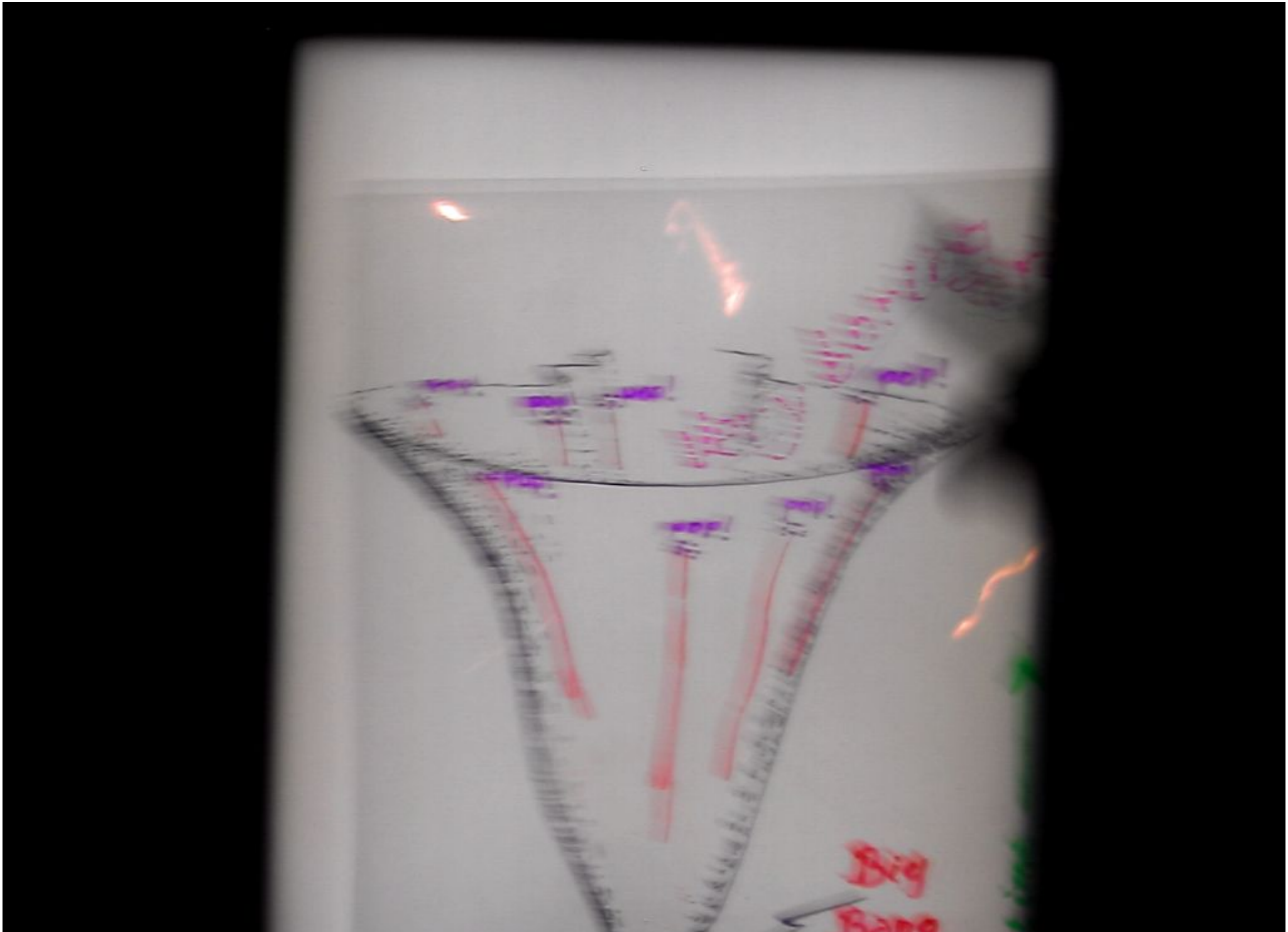
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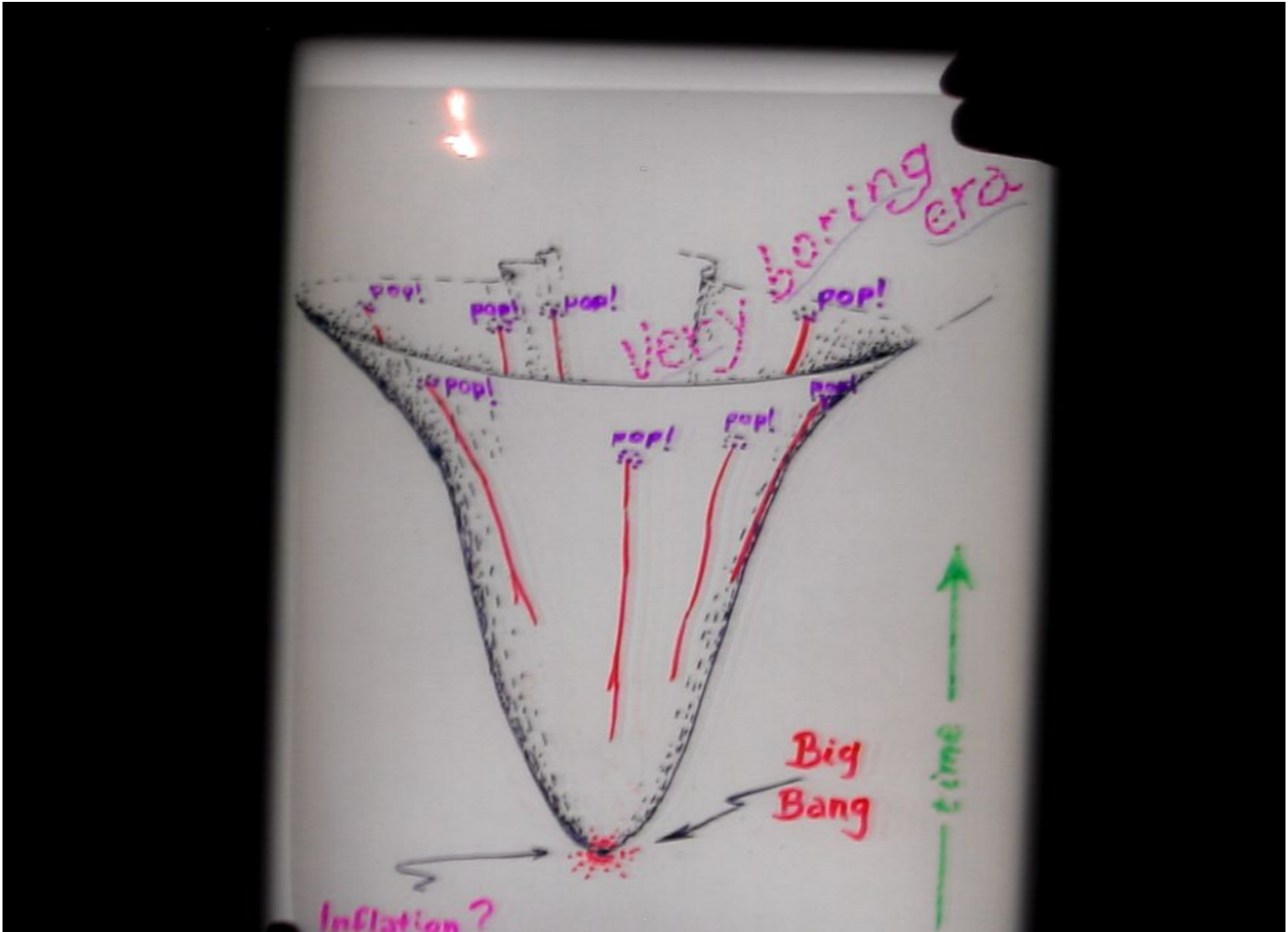
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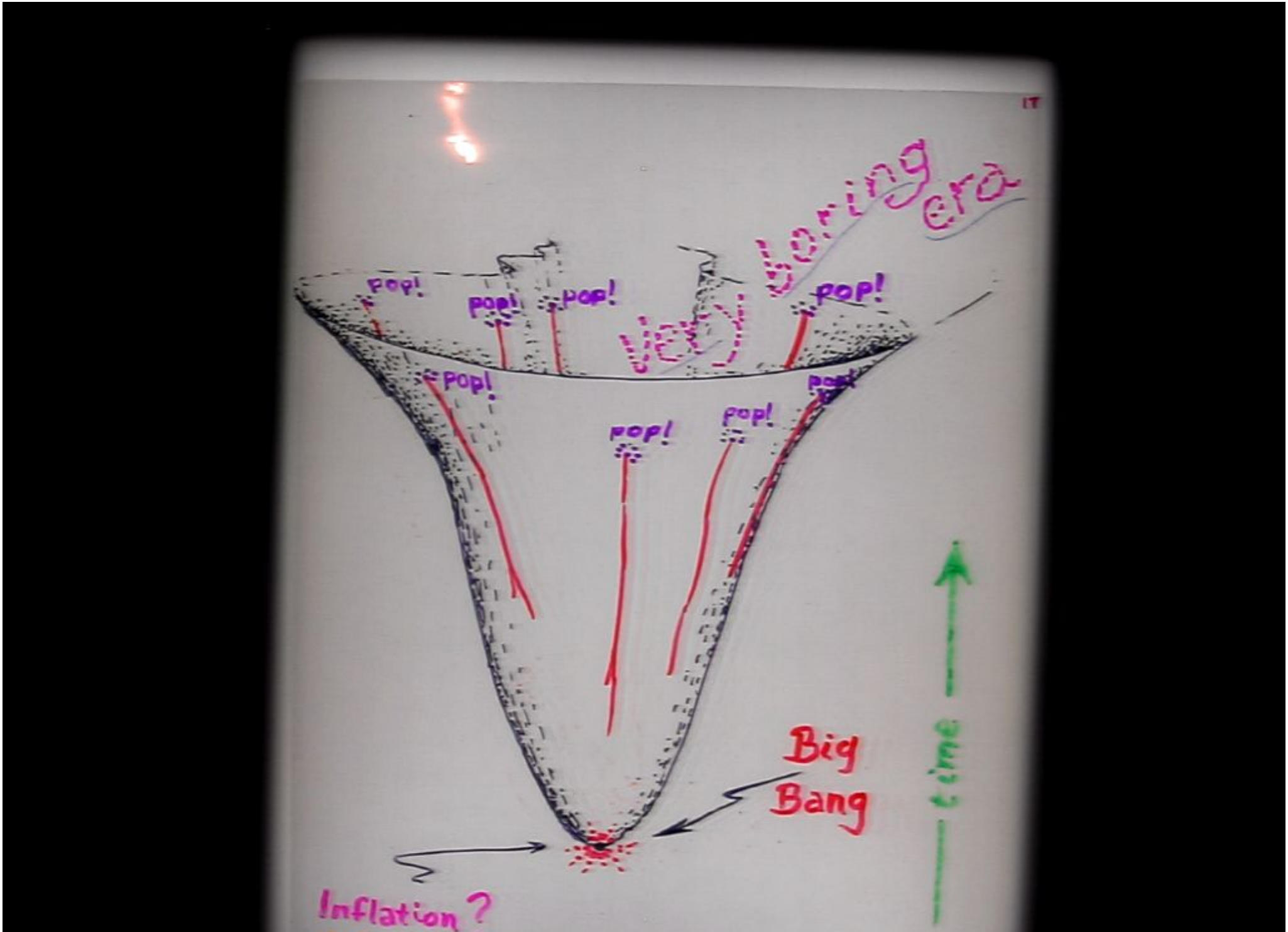
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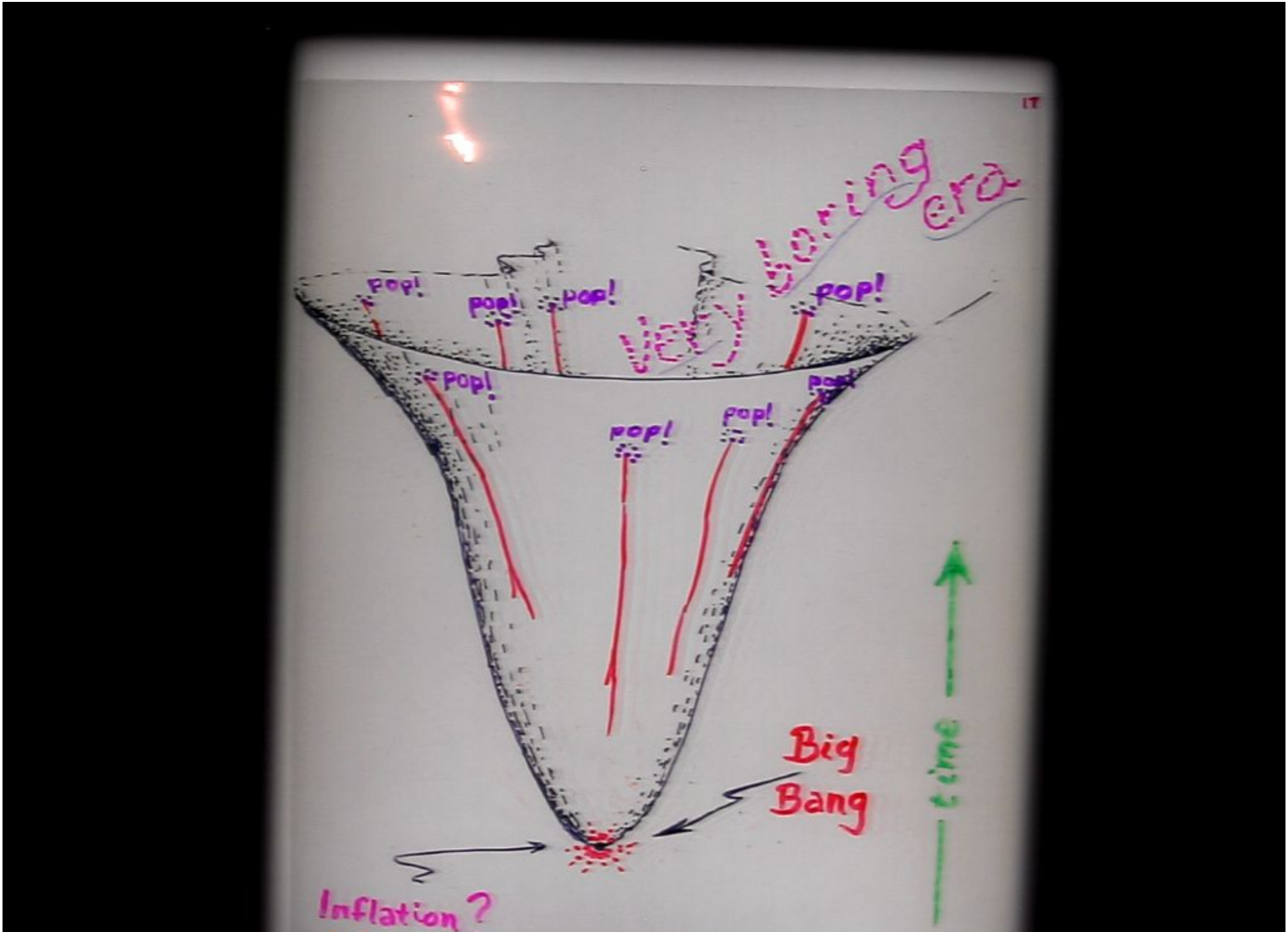
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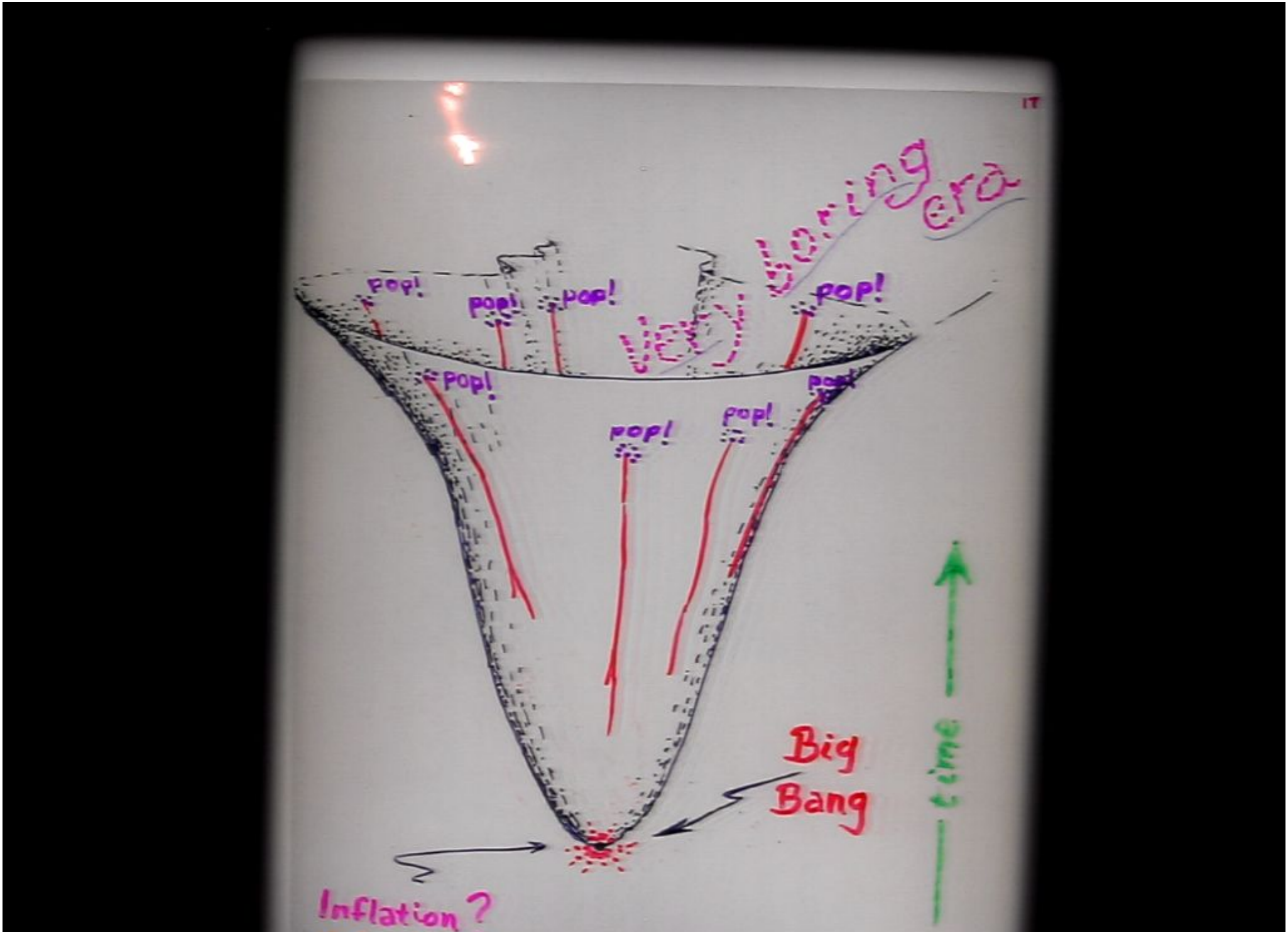
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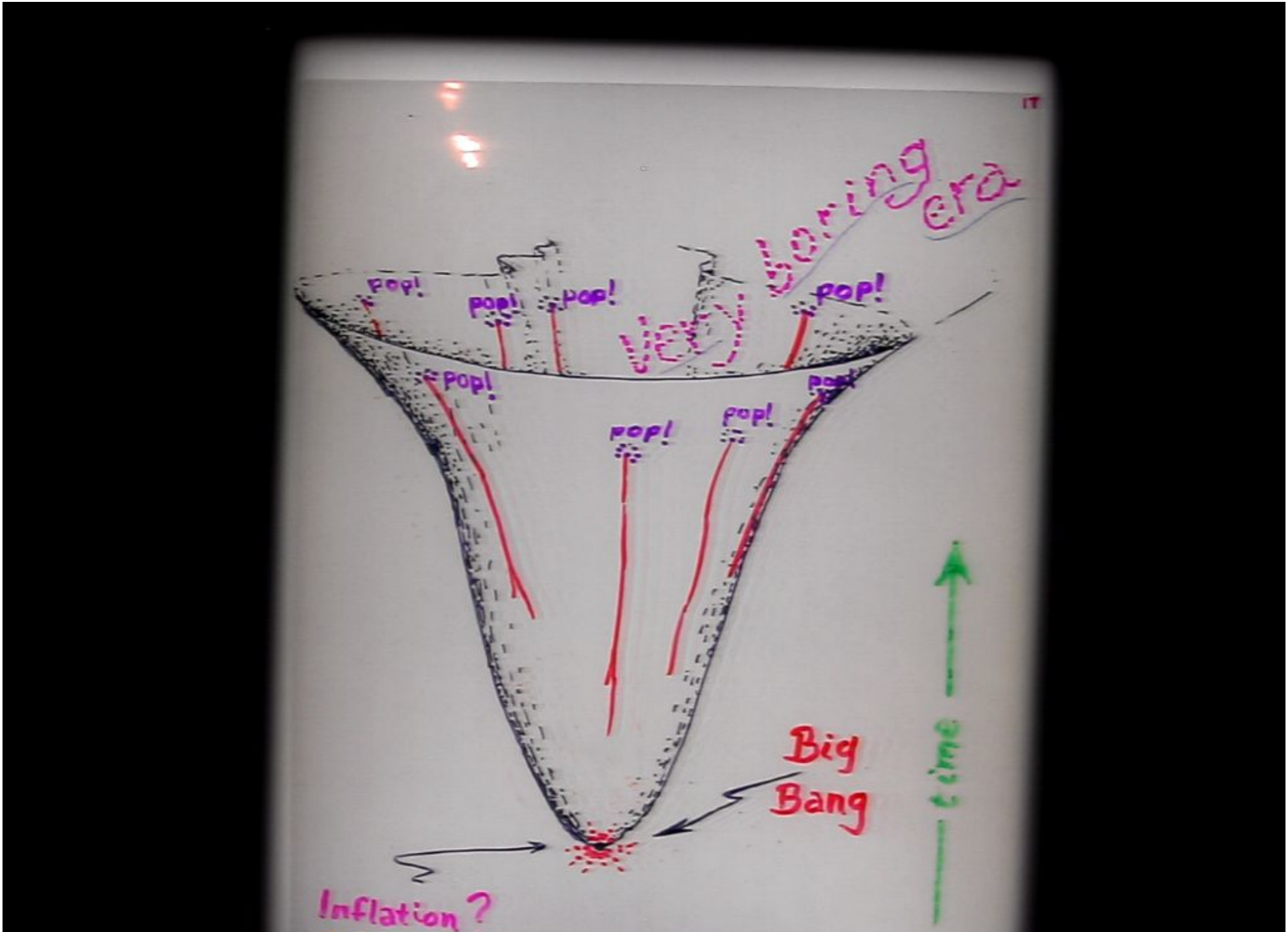
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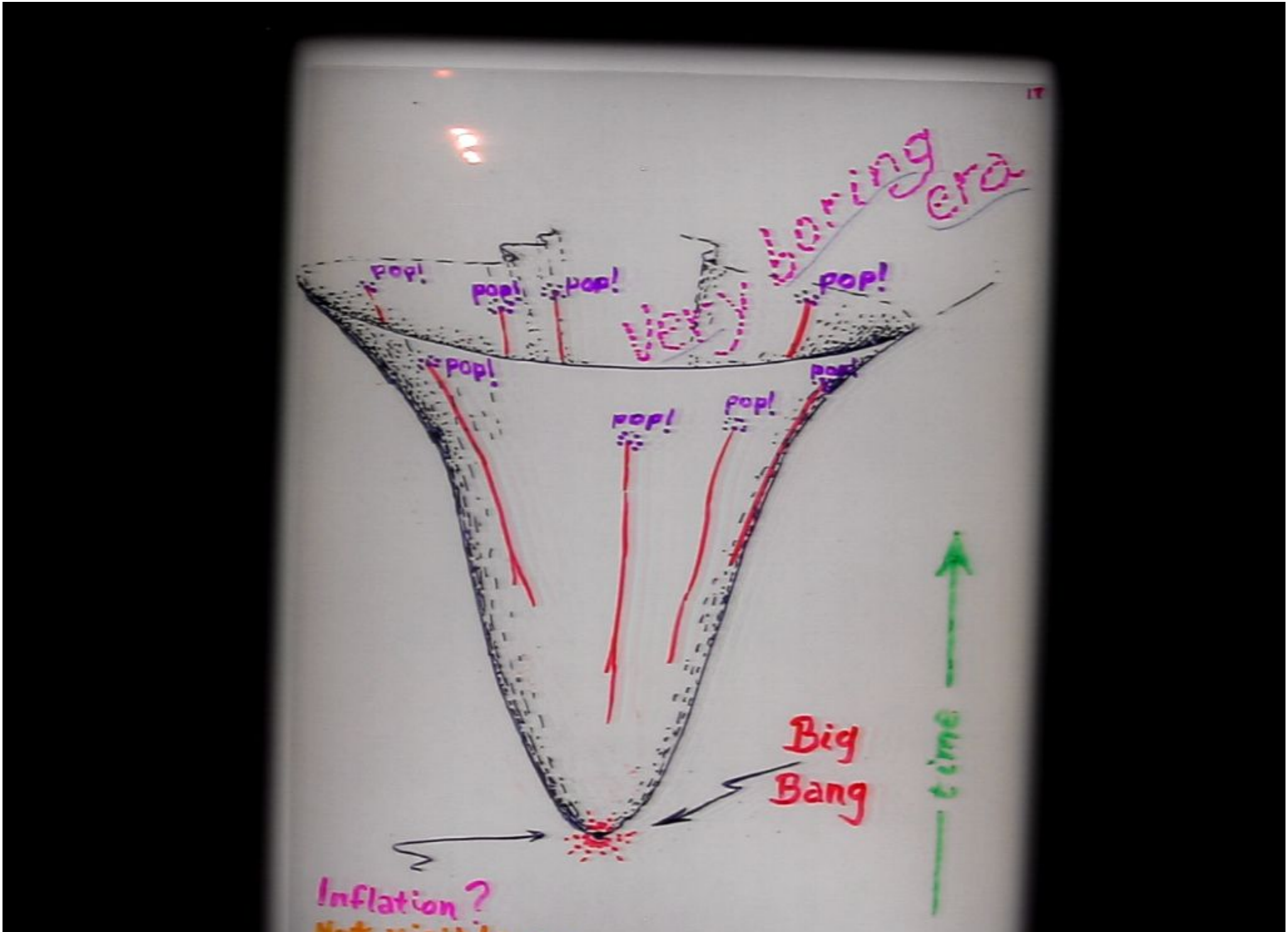
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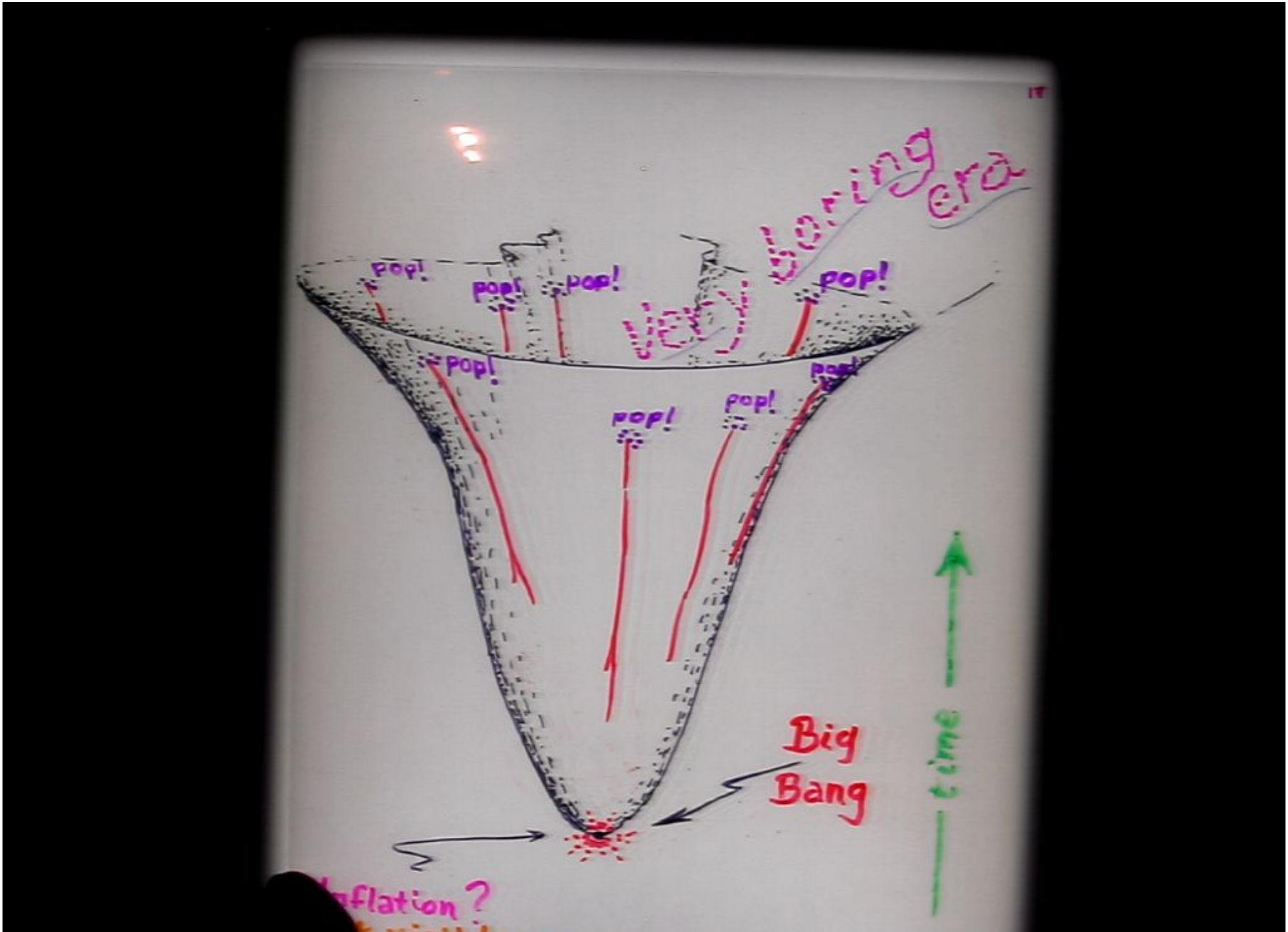
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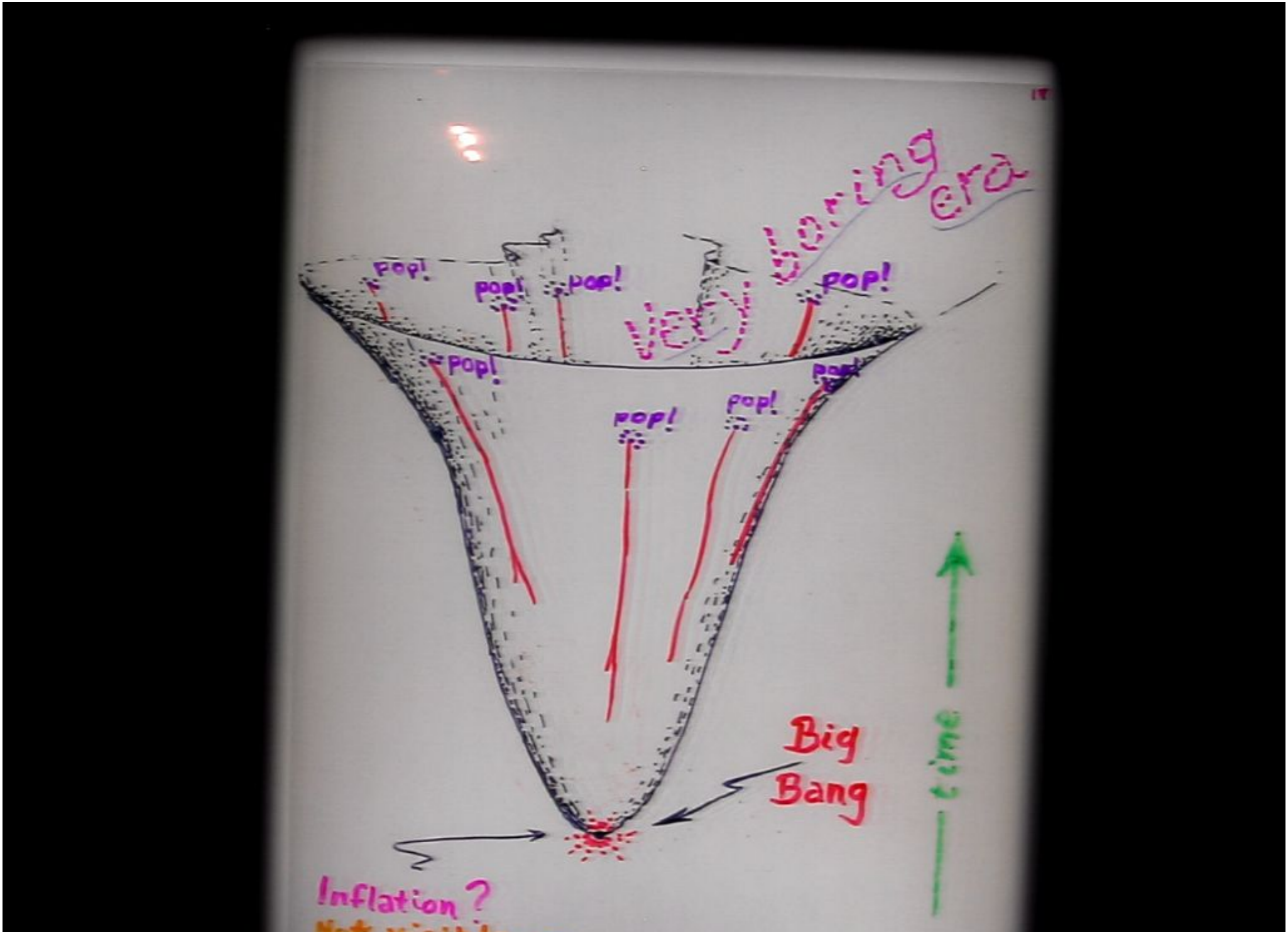
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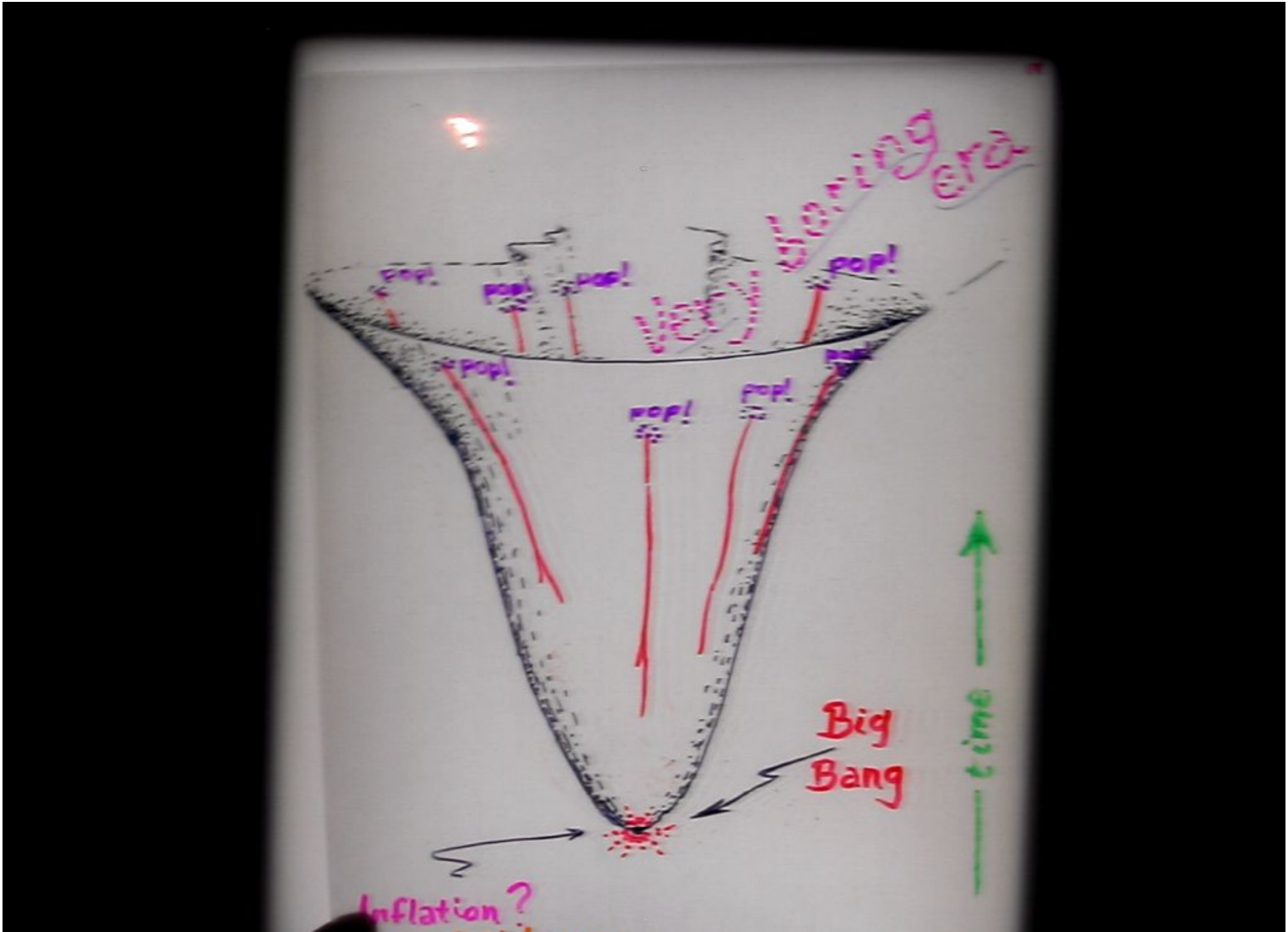
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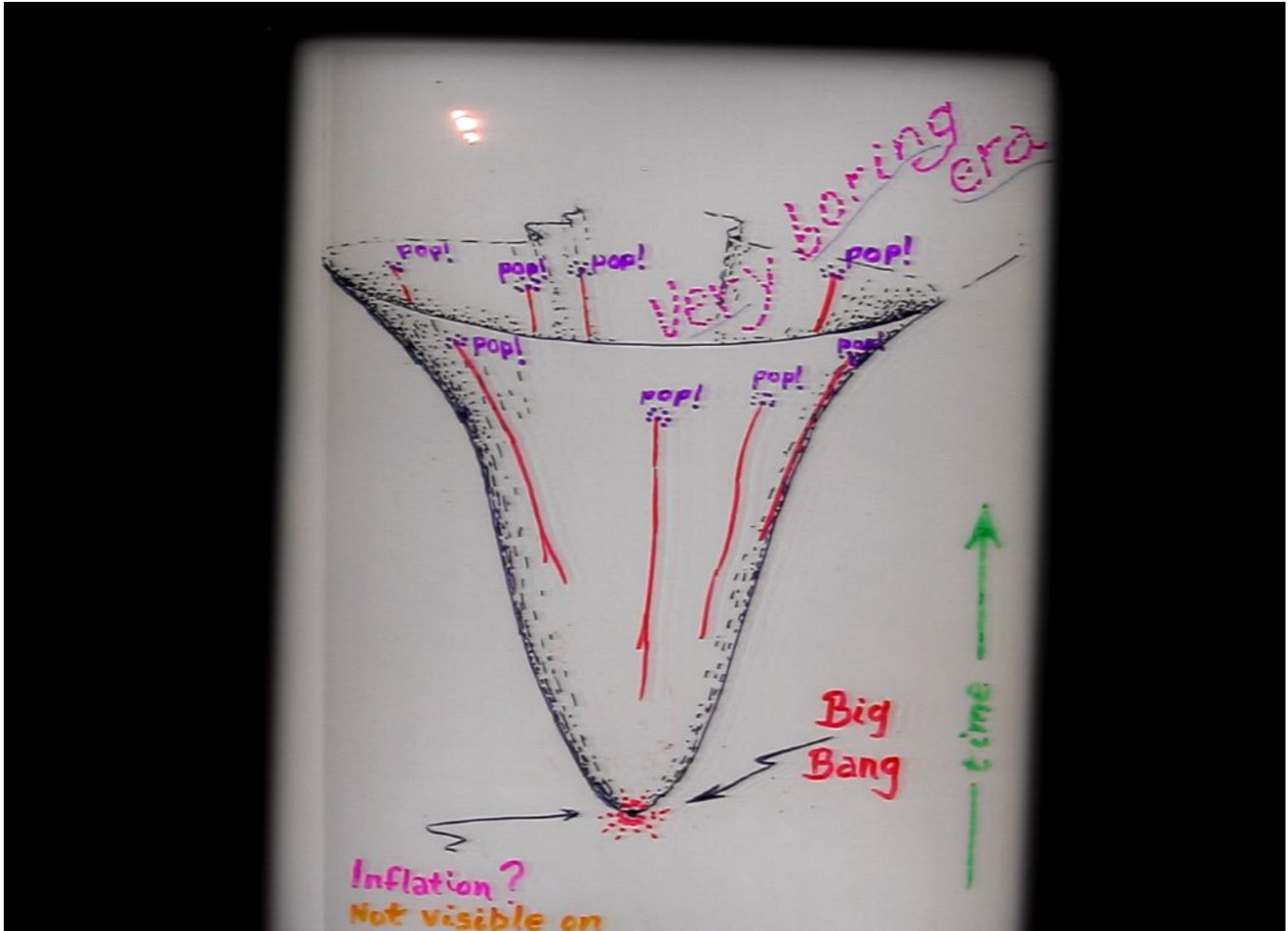
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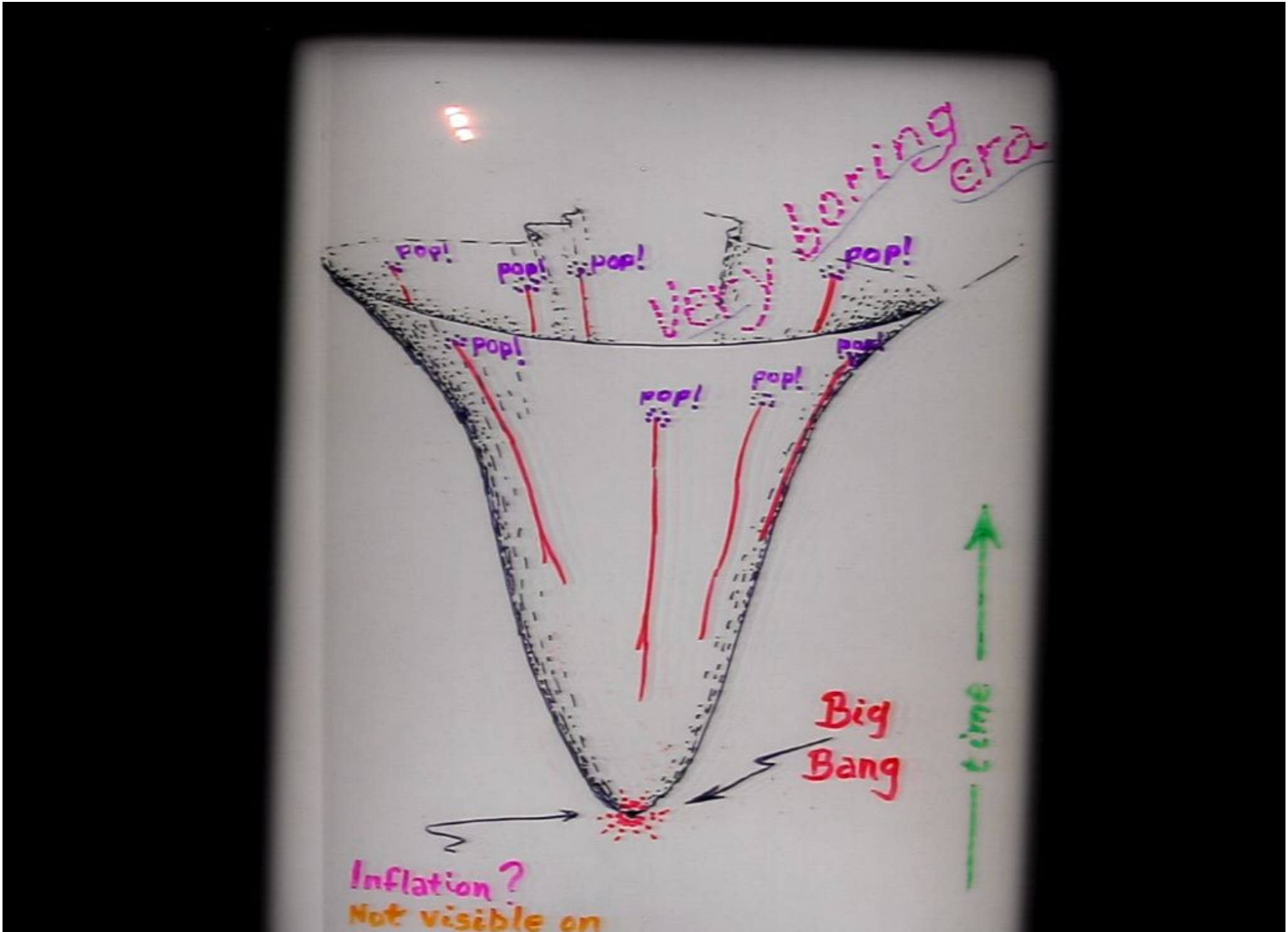
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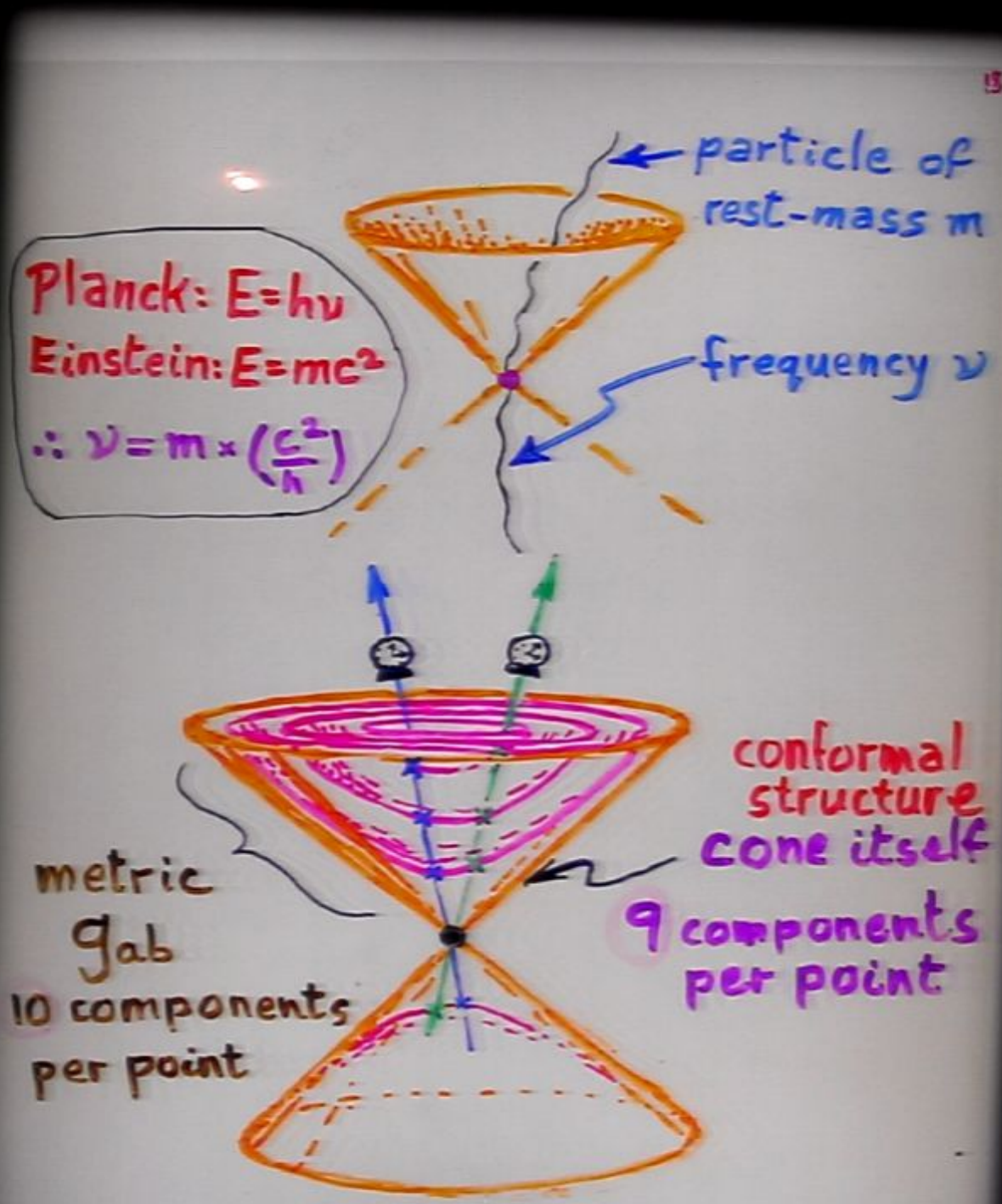
particle of
rest-mass m
Planck: E=hν
Einstein: E=mc²
∴ ν = m × (c²/h)
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cone itself
9 components
per point
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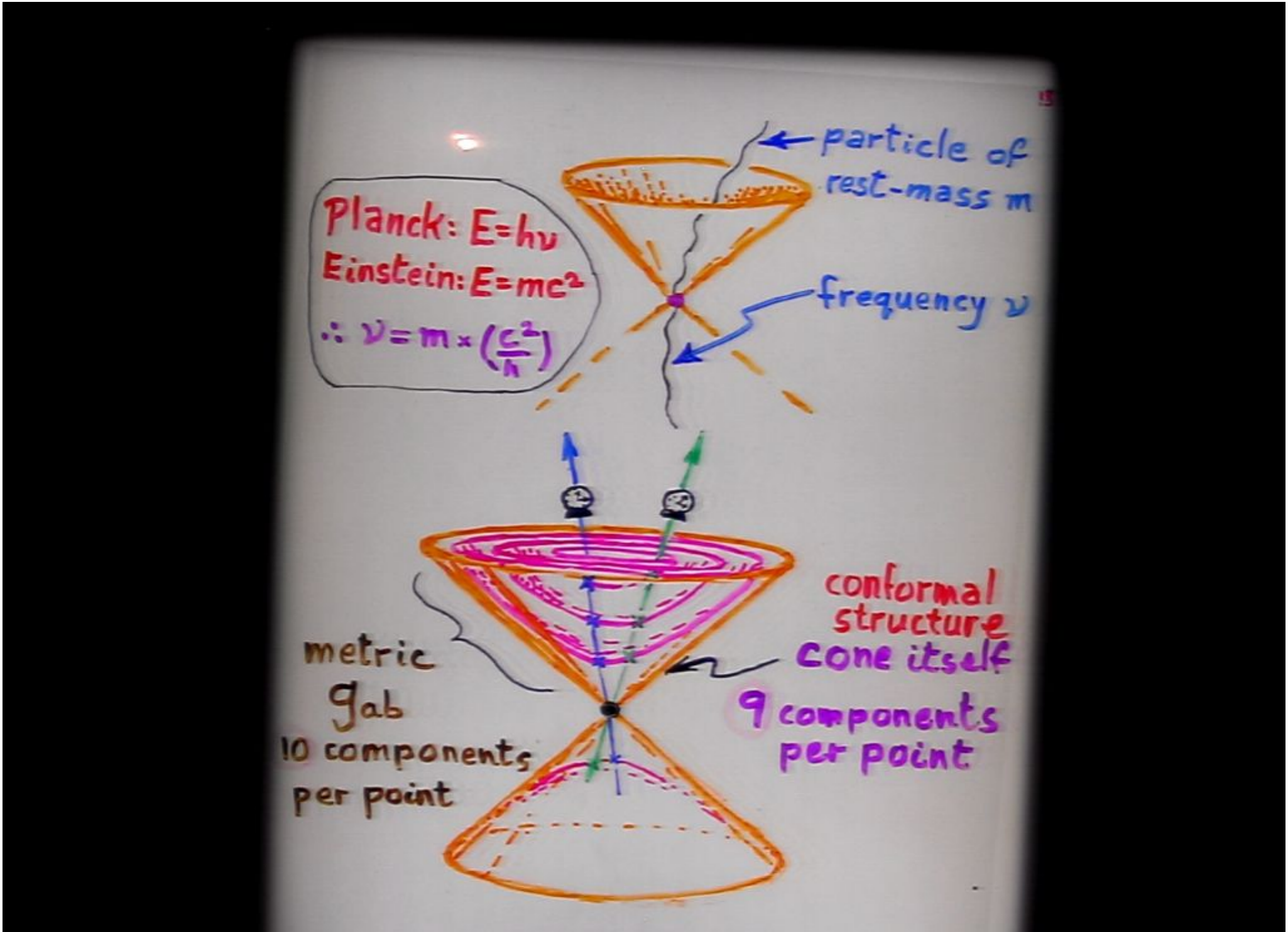
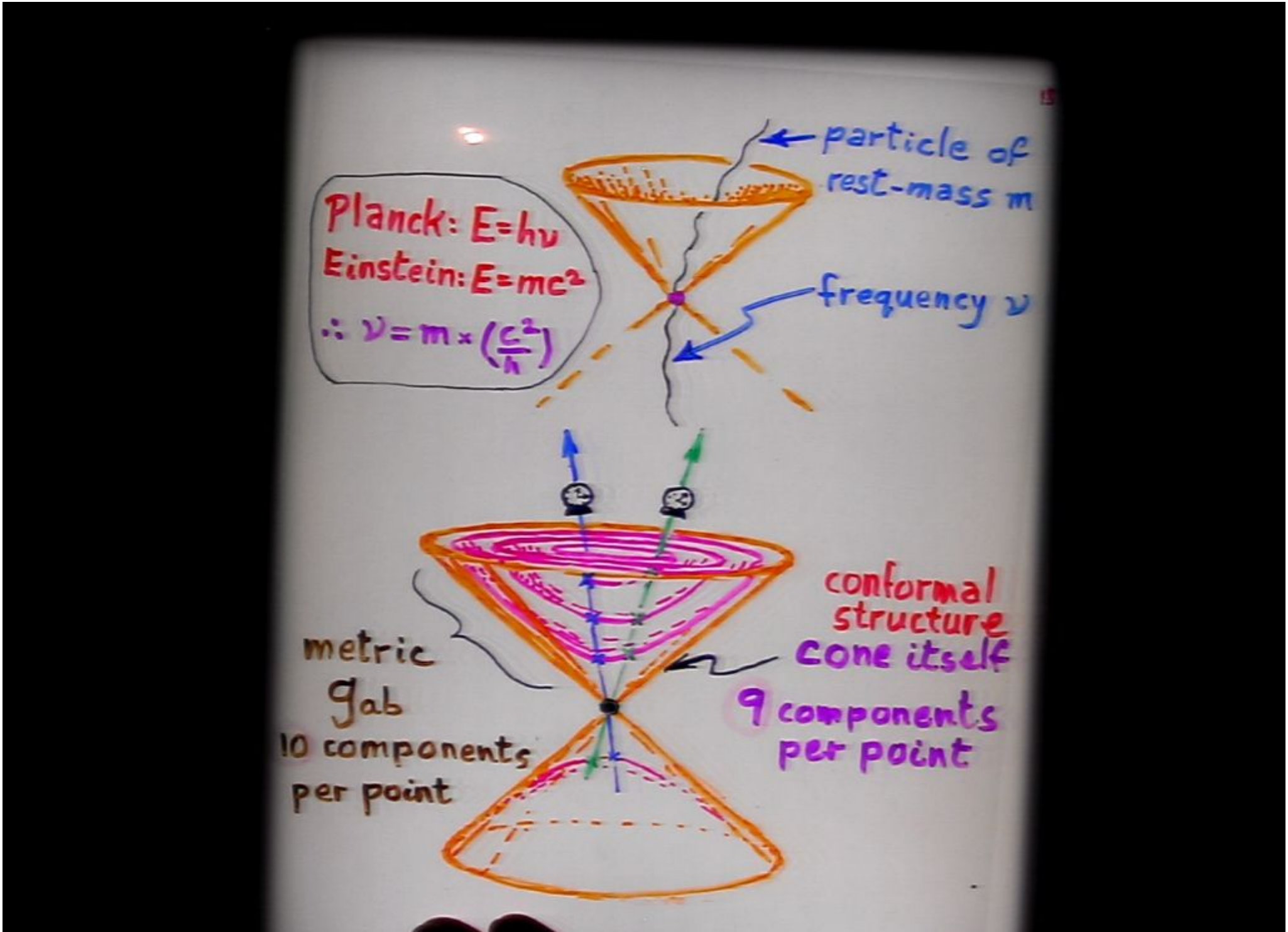
per point


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


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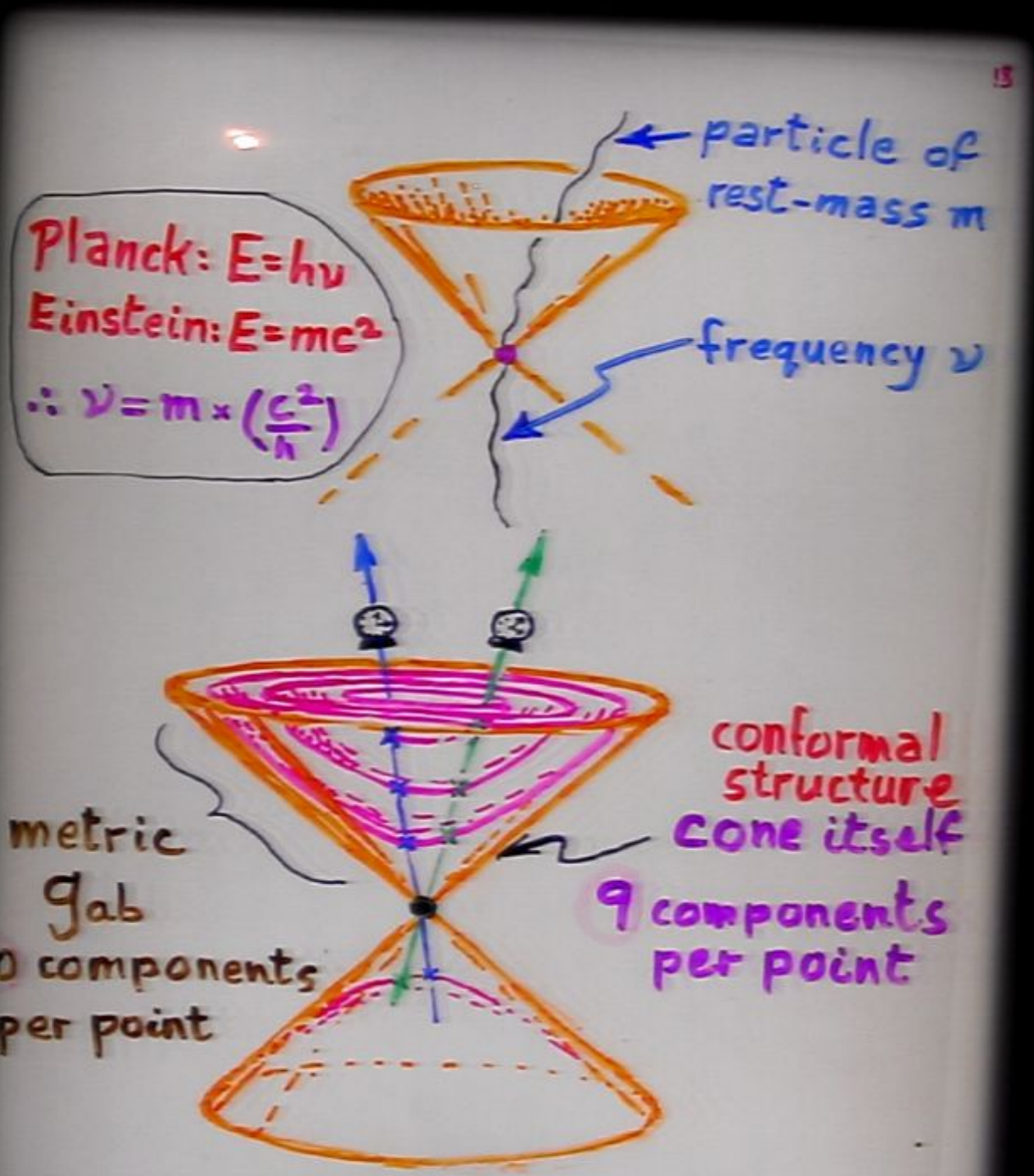
particle of rest-mass m
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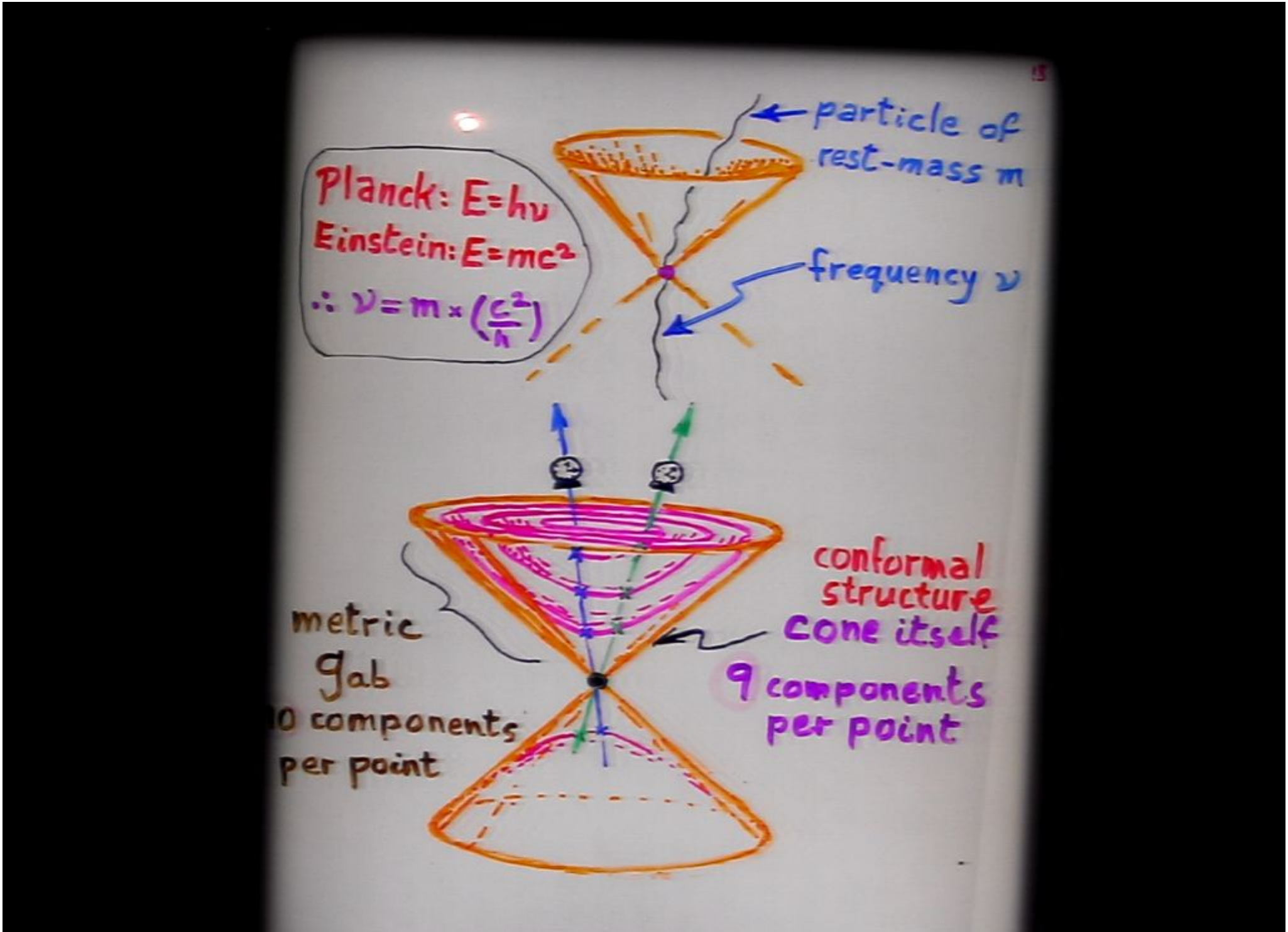
Planck: E=hν
Einstein: E=mc²
∴ ν=m×(c²/h)
conformal structure cone itself
9 components per point
metric g_ab
10 components per point


Planck: $E=h\nu$
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particle of rest-mass m
frequency ν
metric g_{ab}
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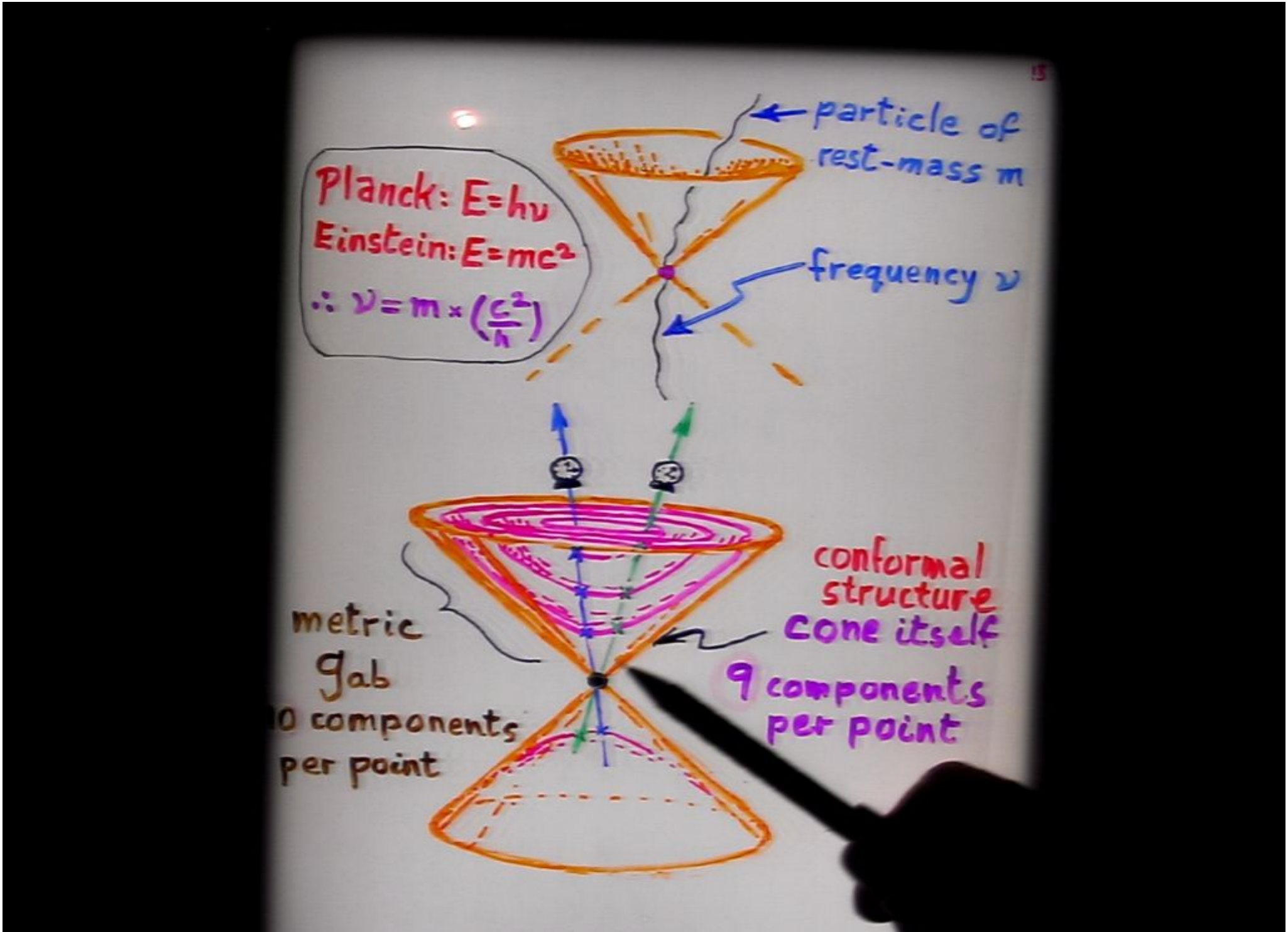
conformal structure
cone itself
9 components per point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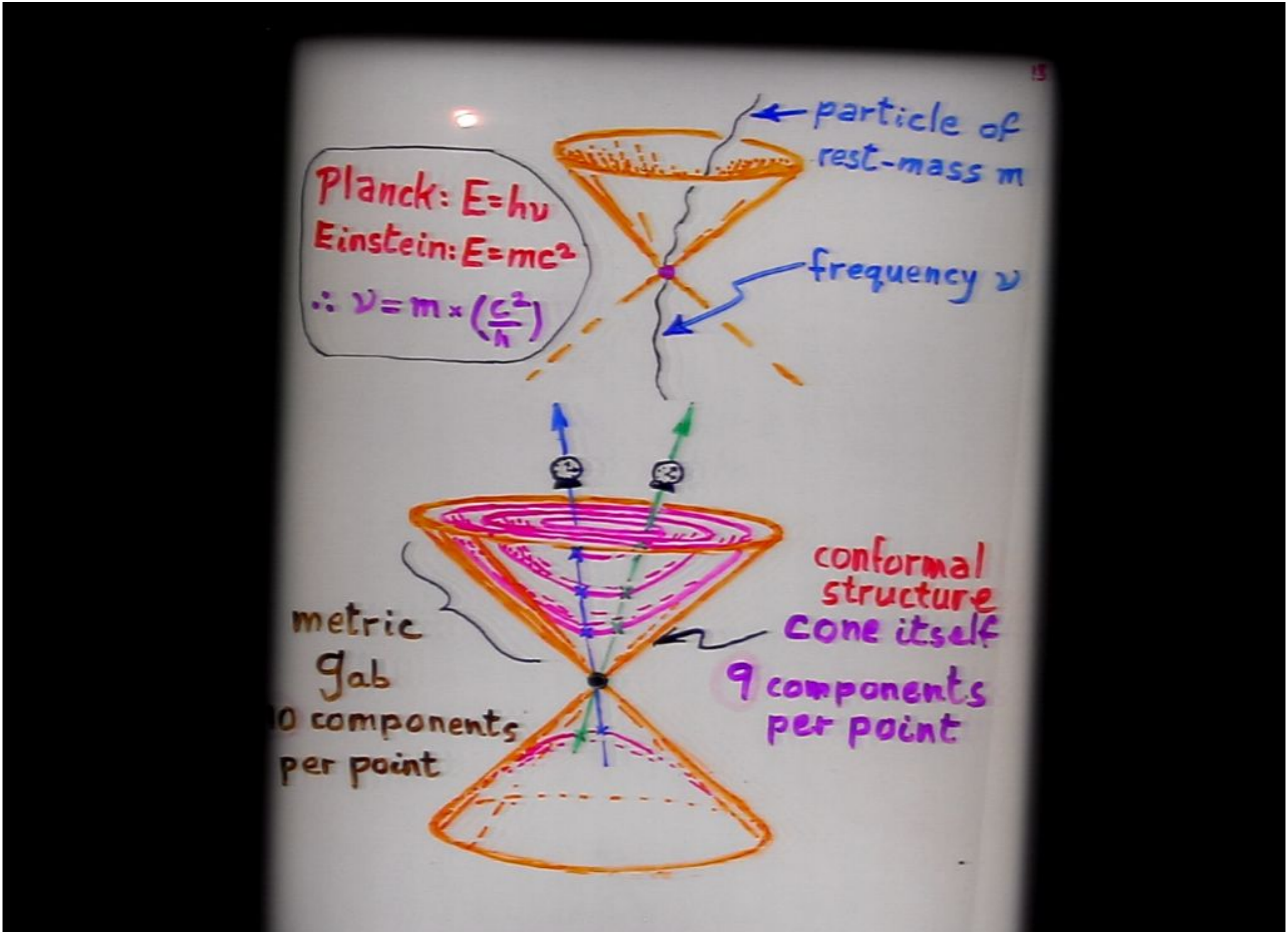
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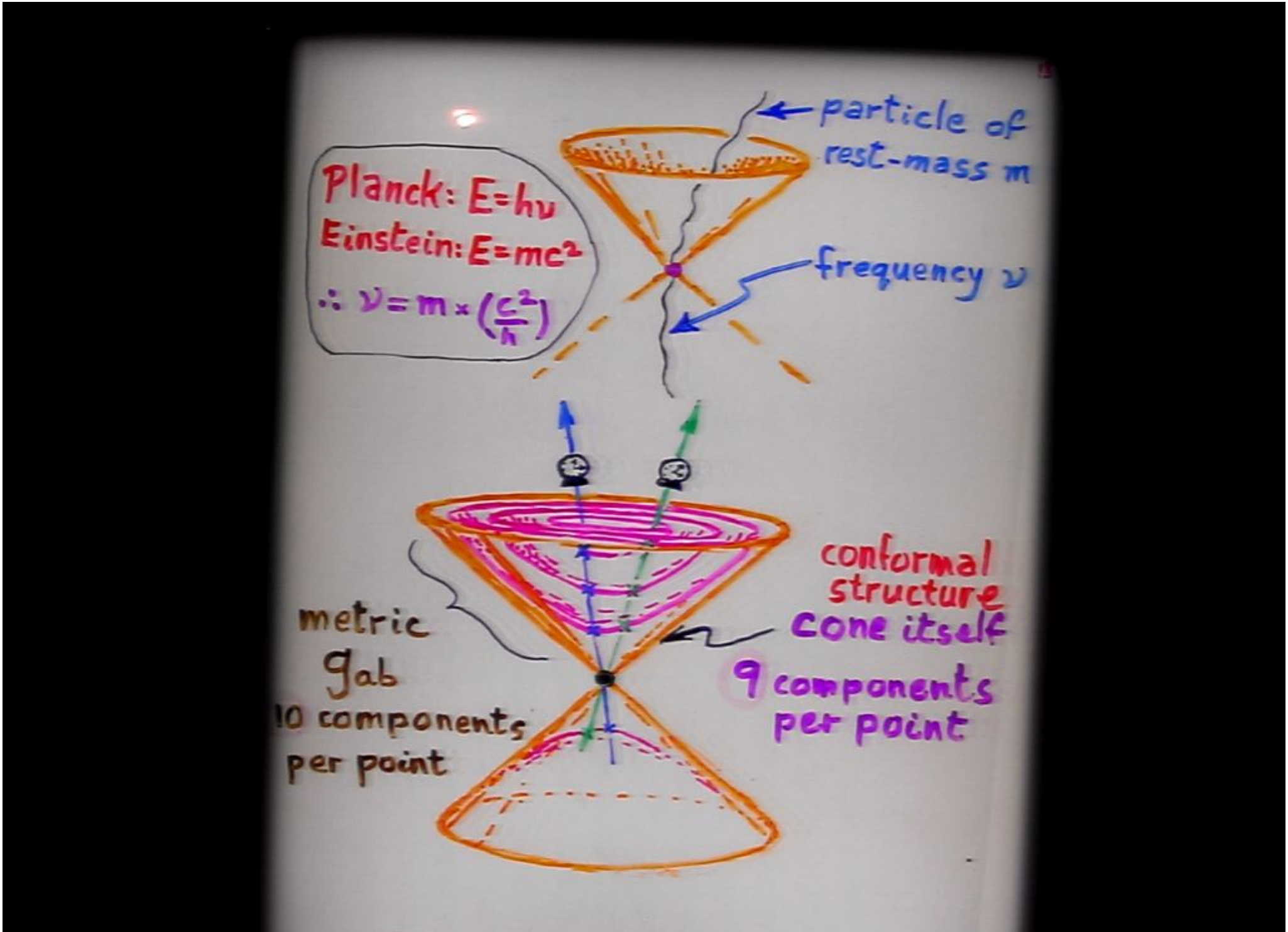
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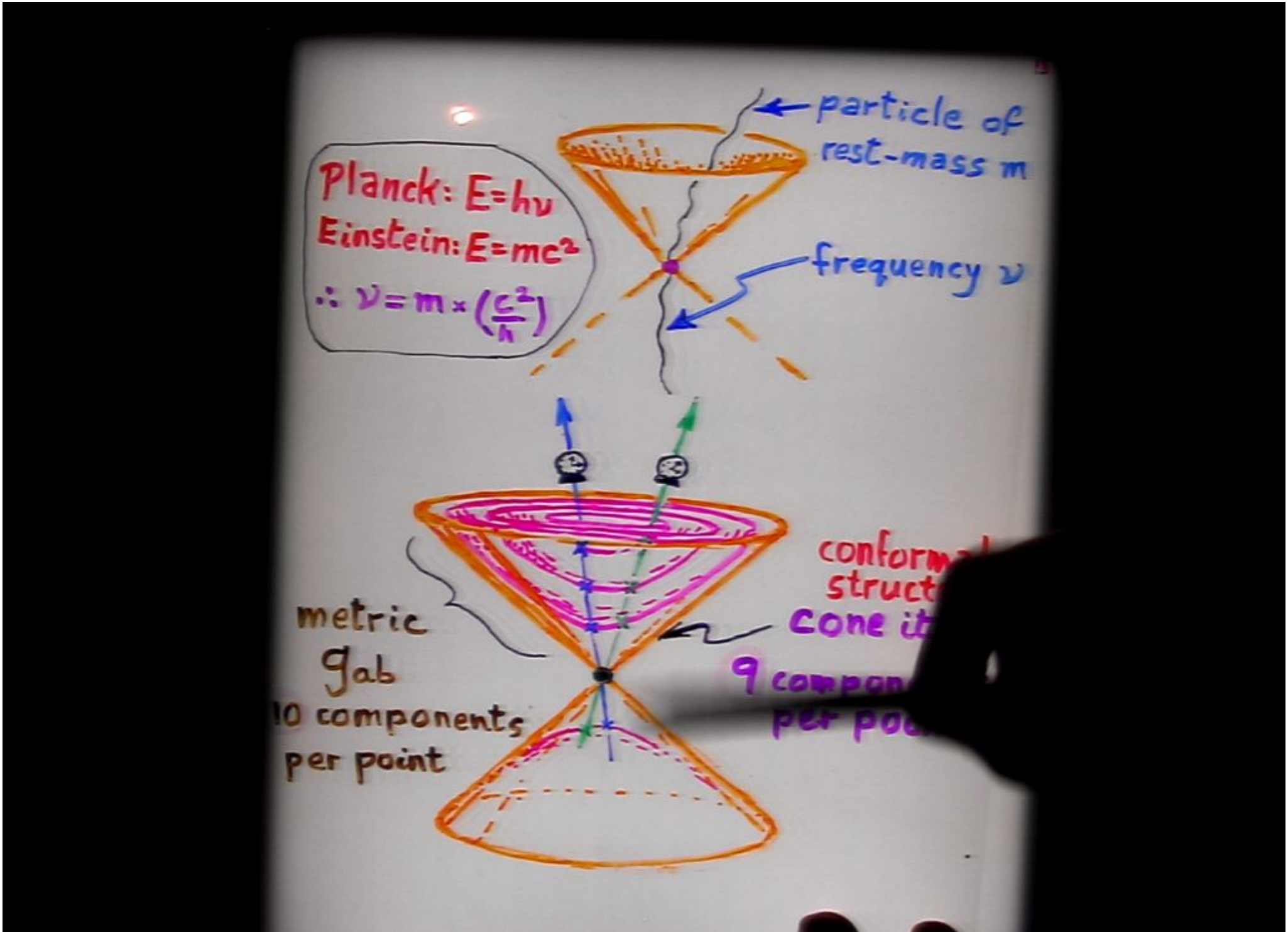
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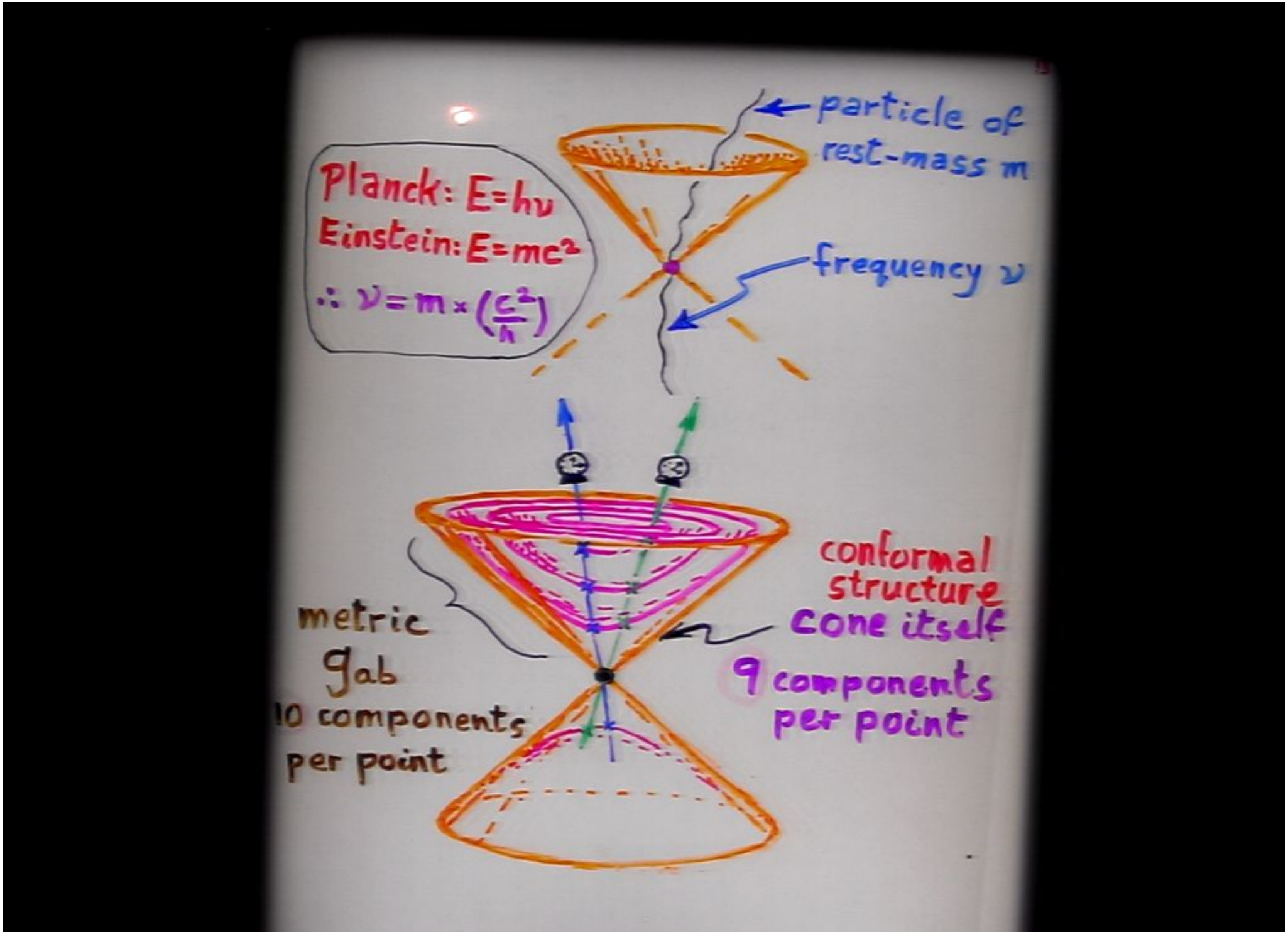
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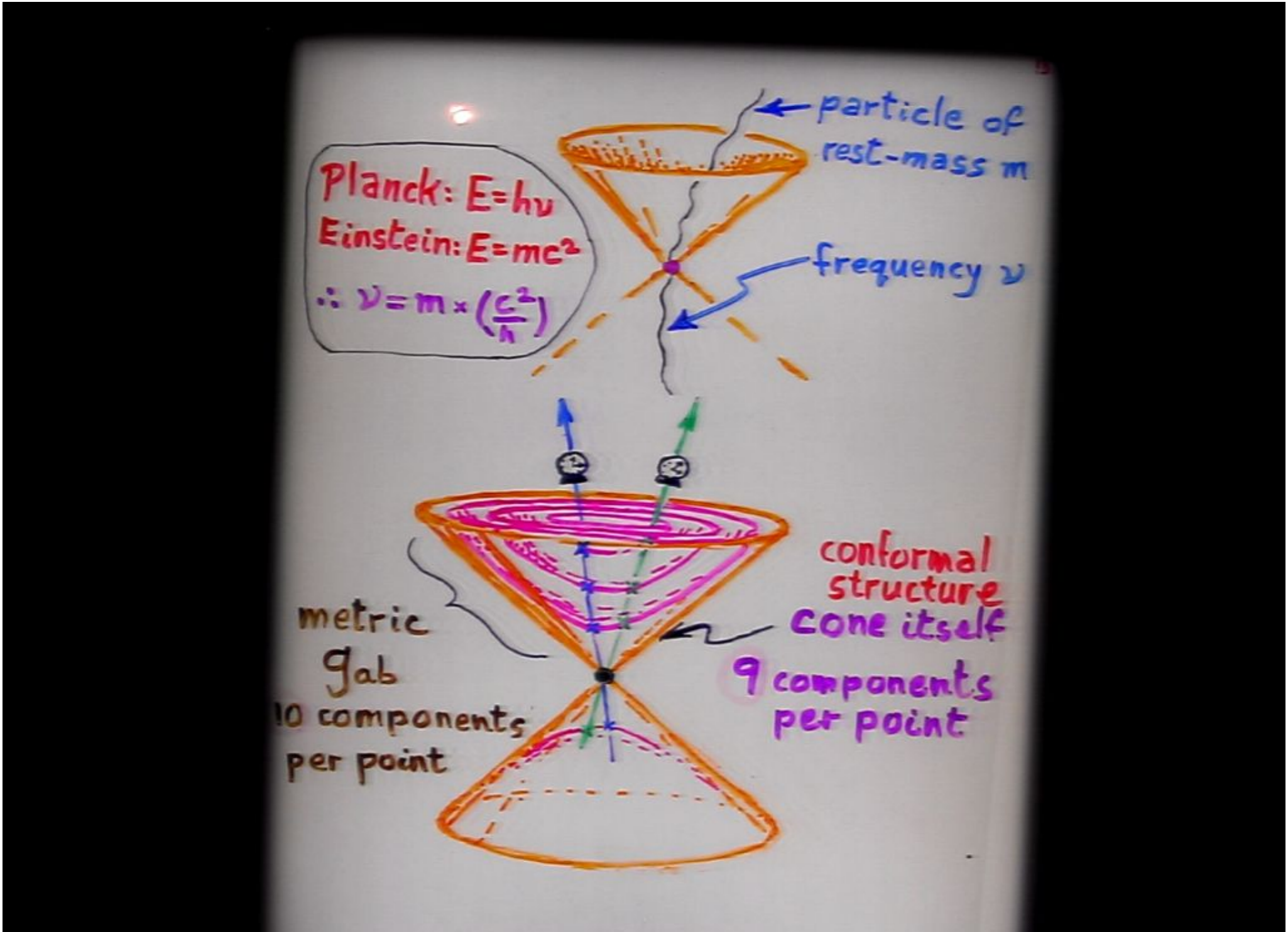
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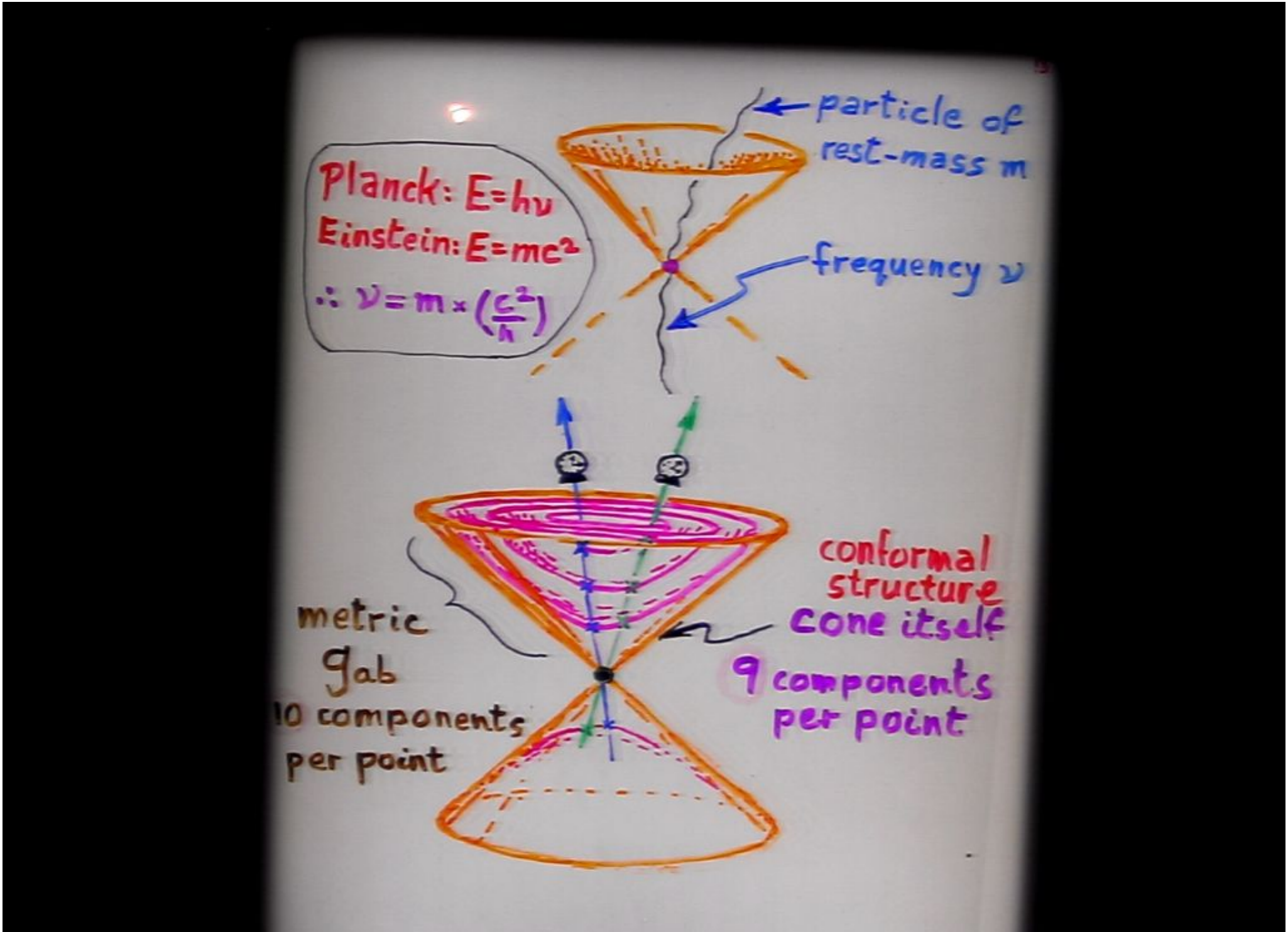
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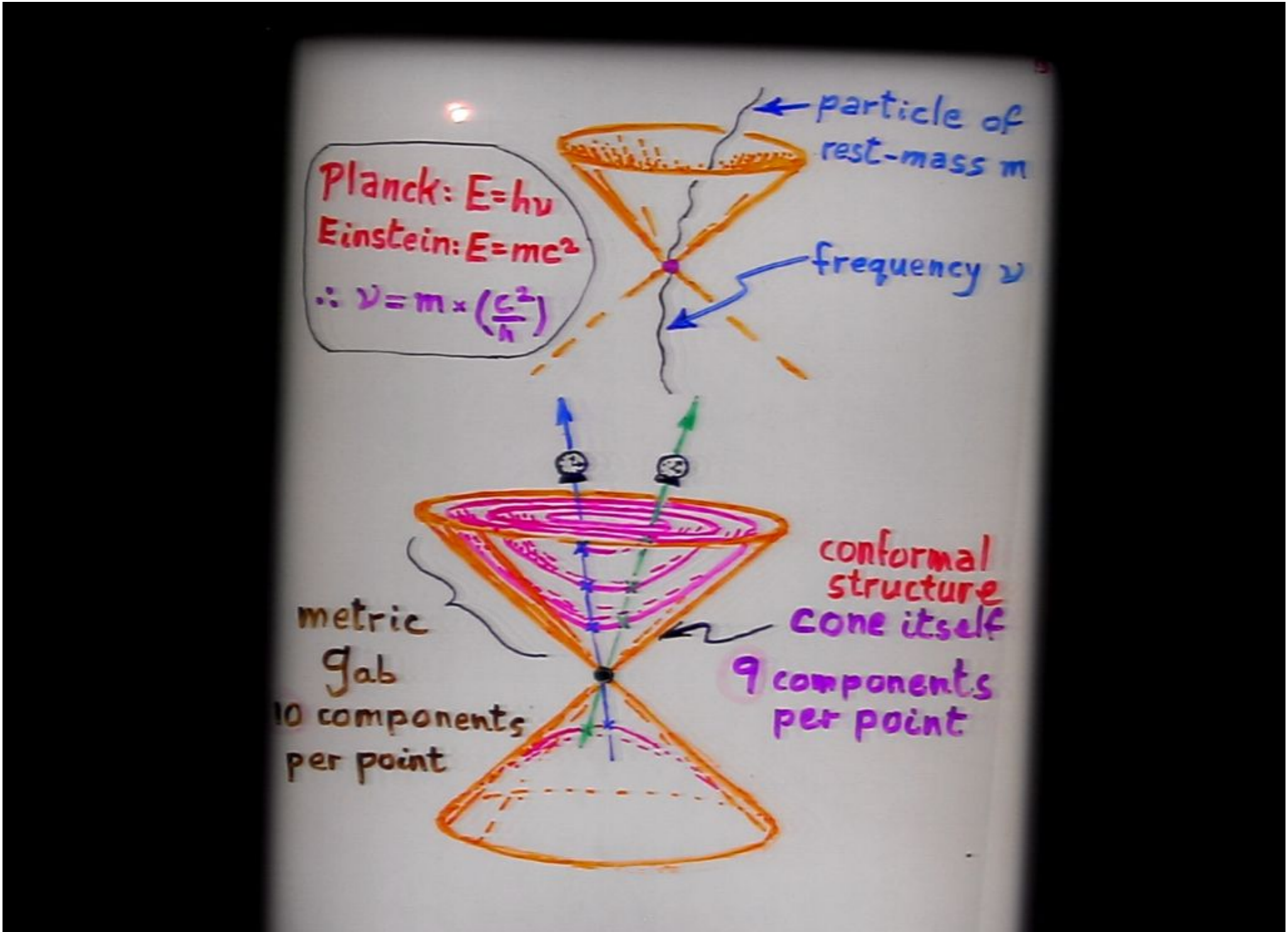
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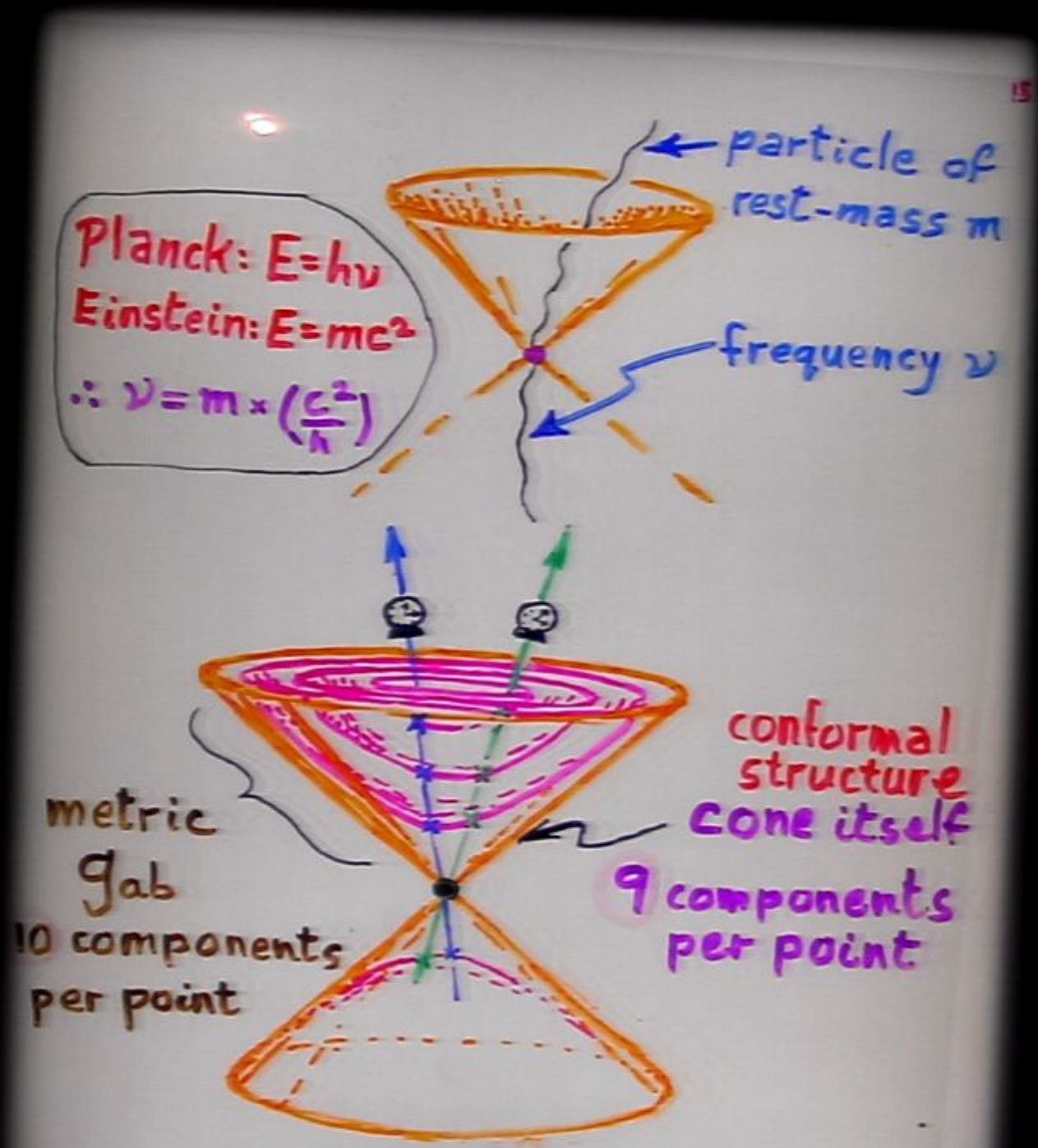
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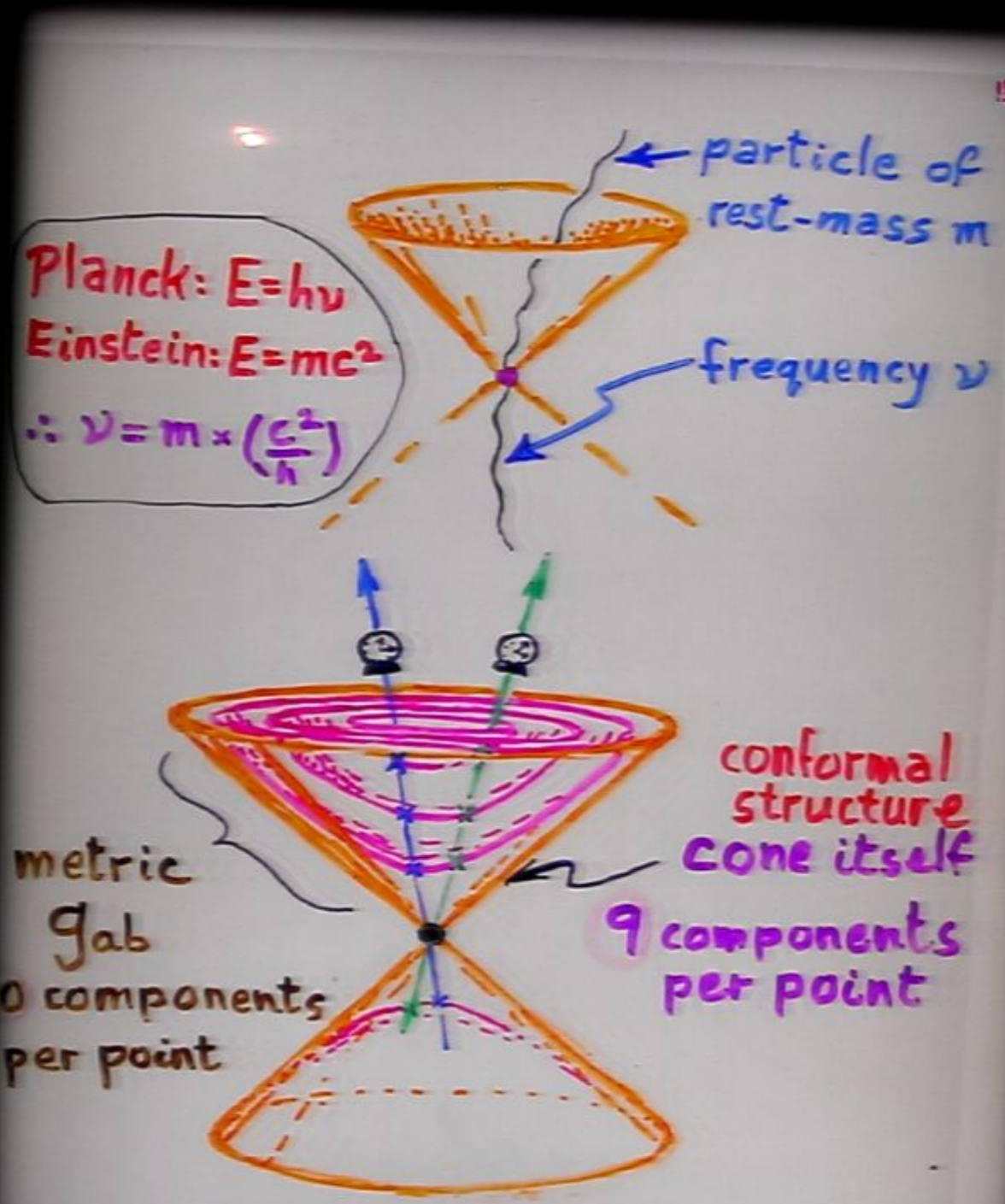
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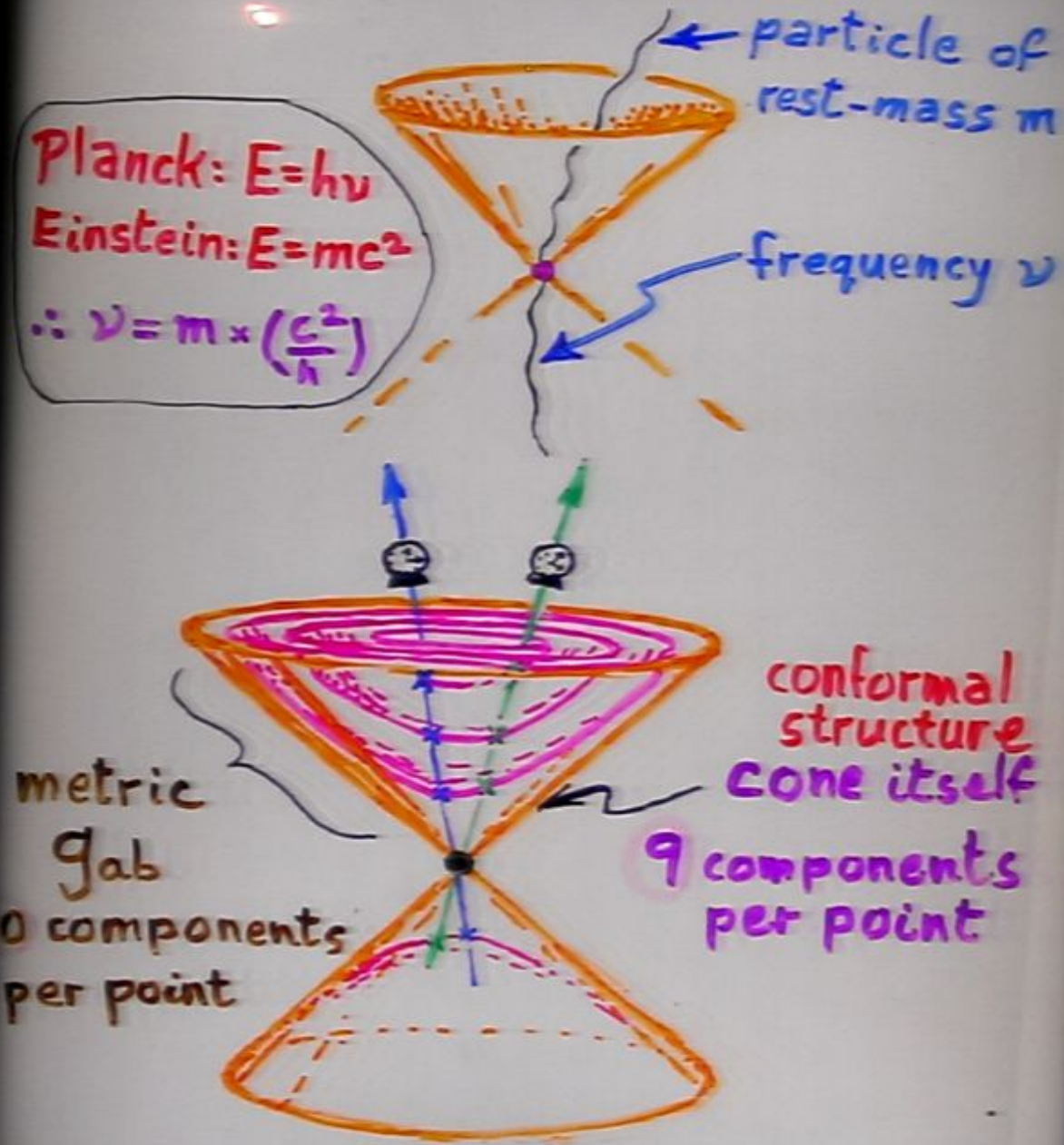
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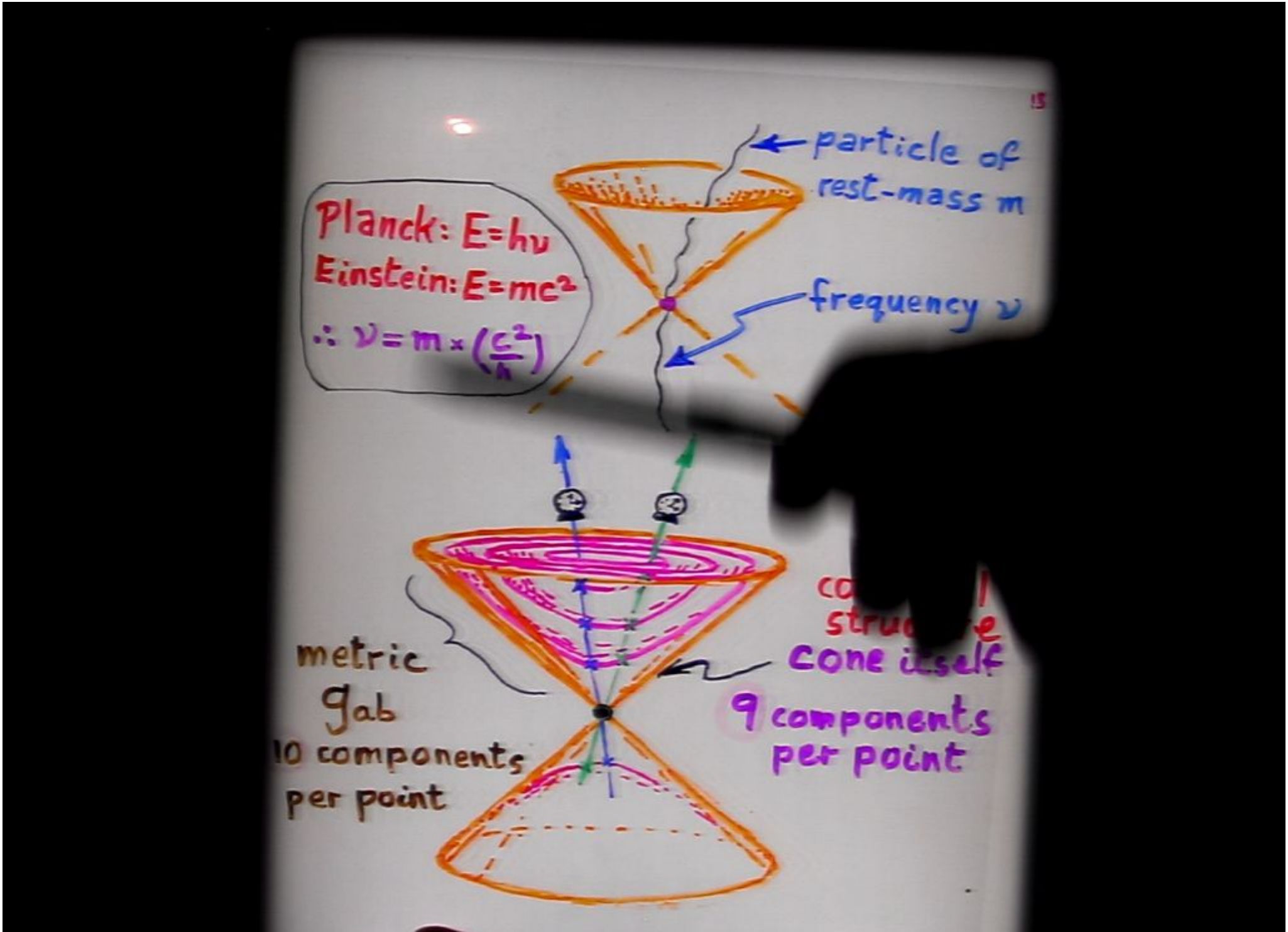
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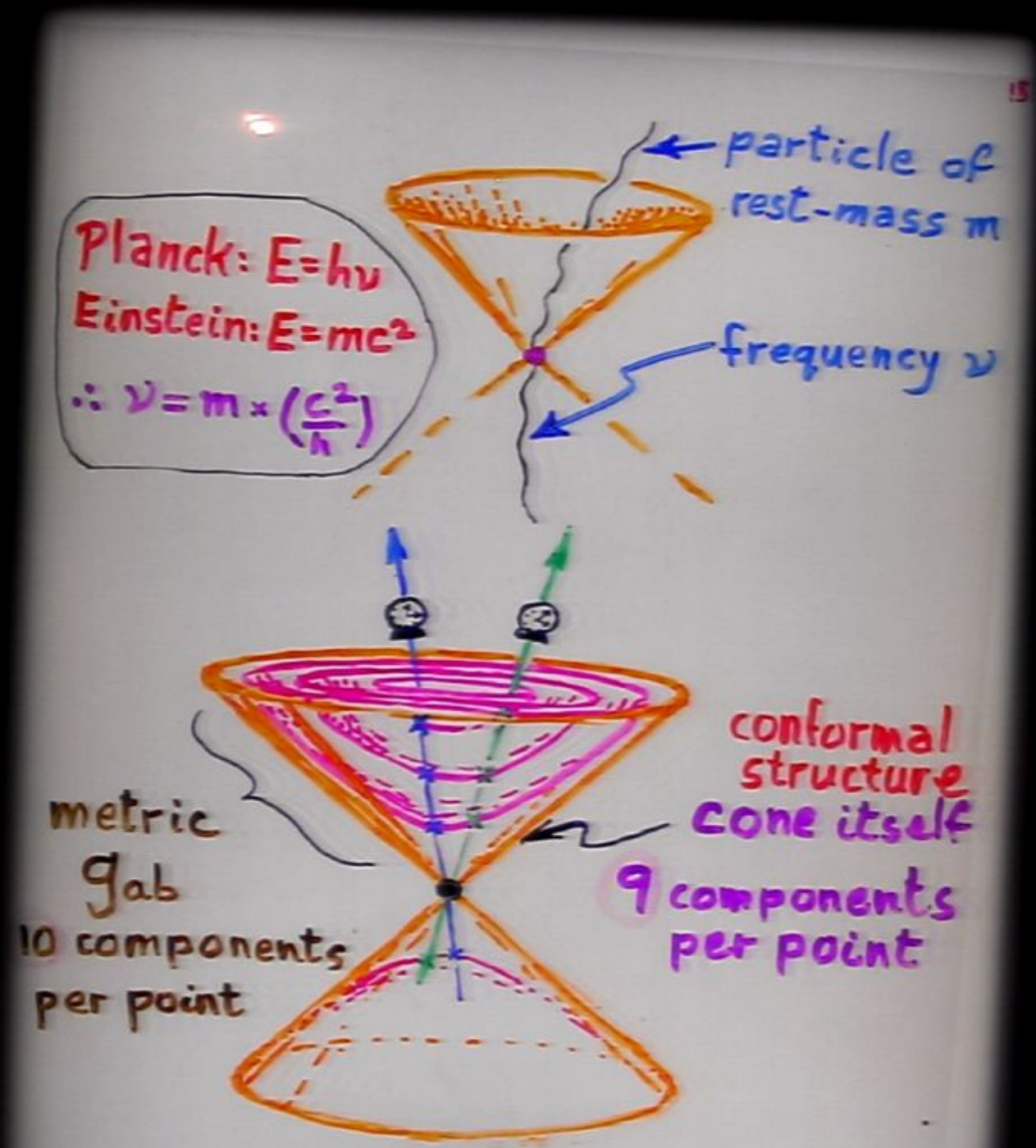
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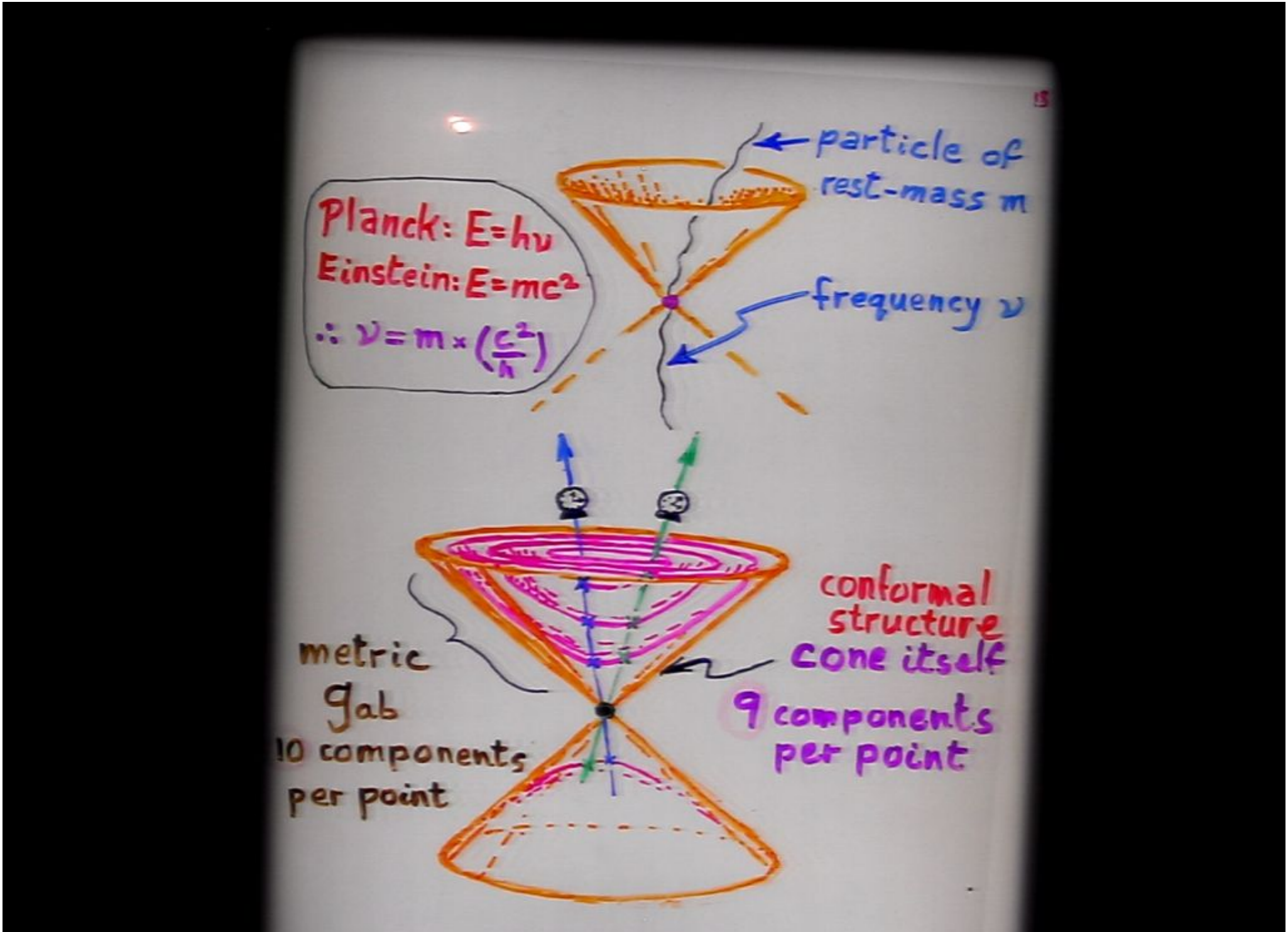
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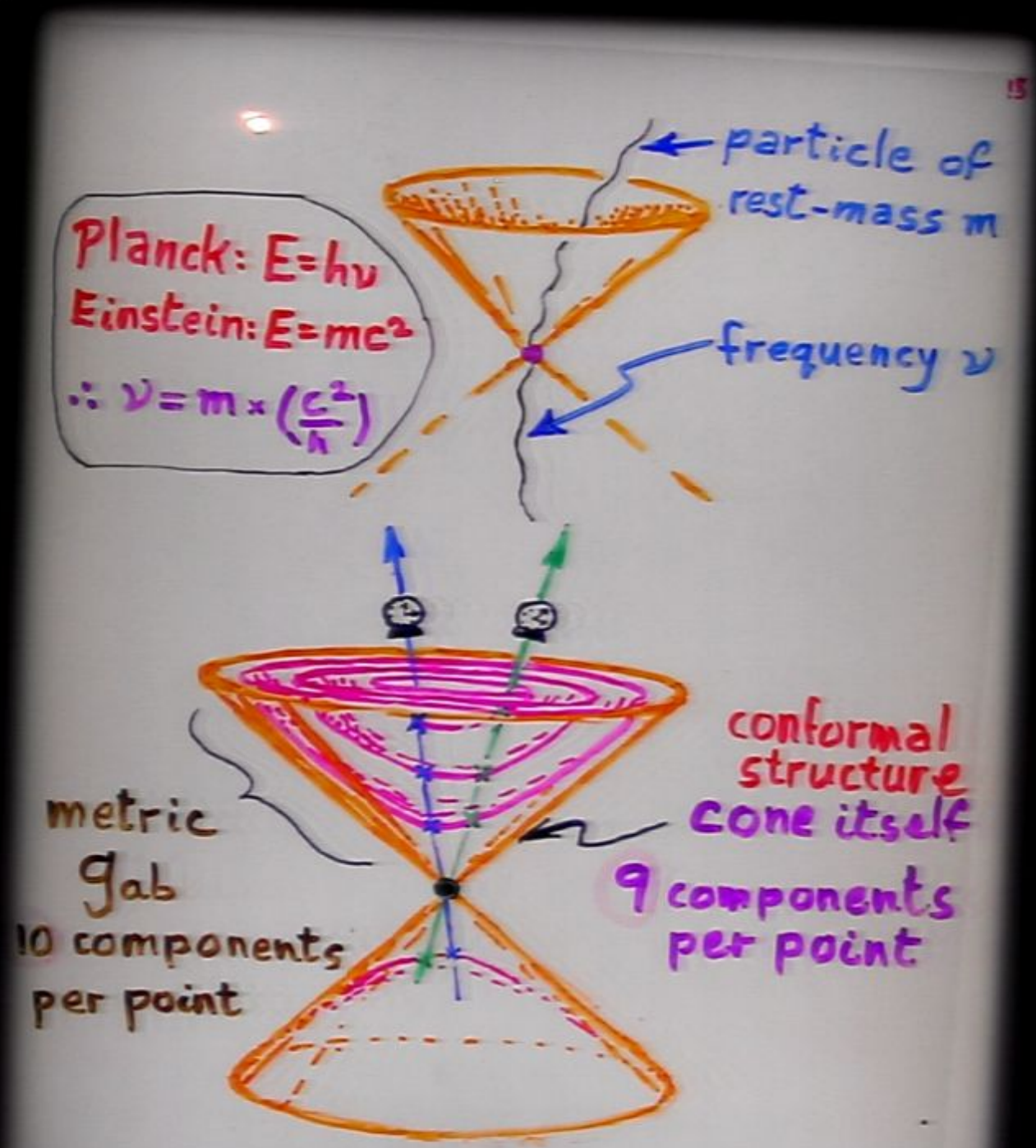
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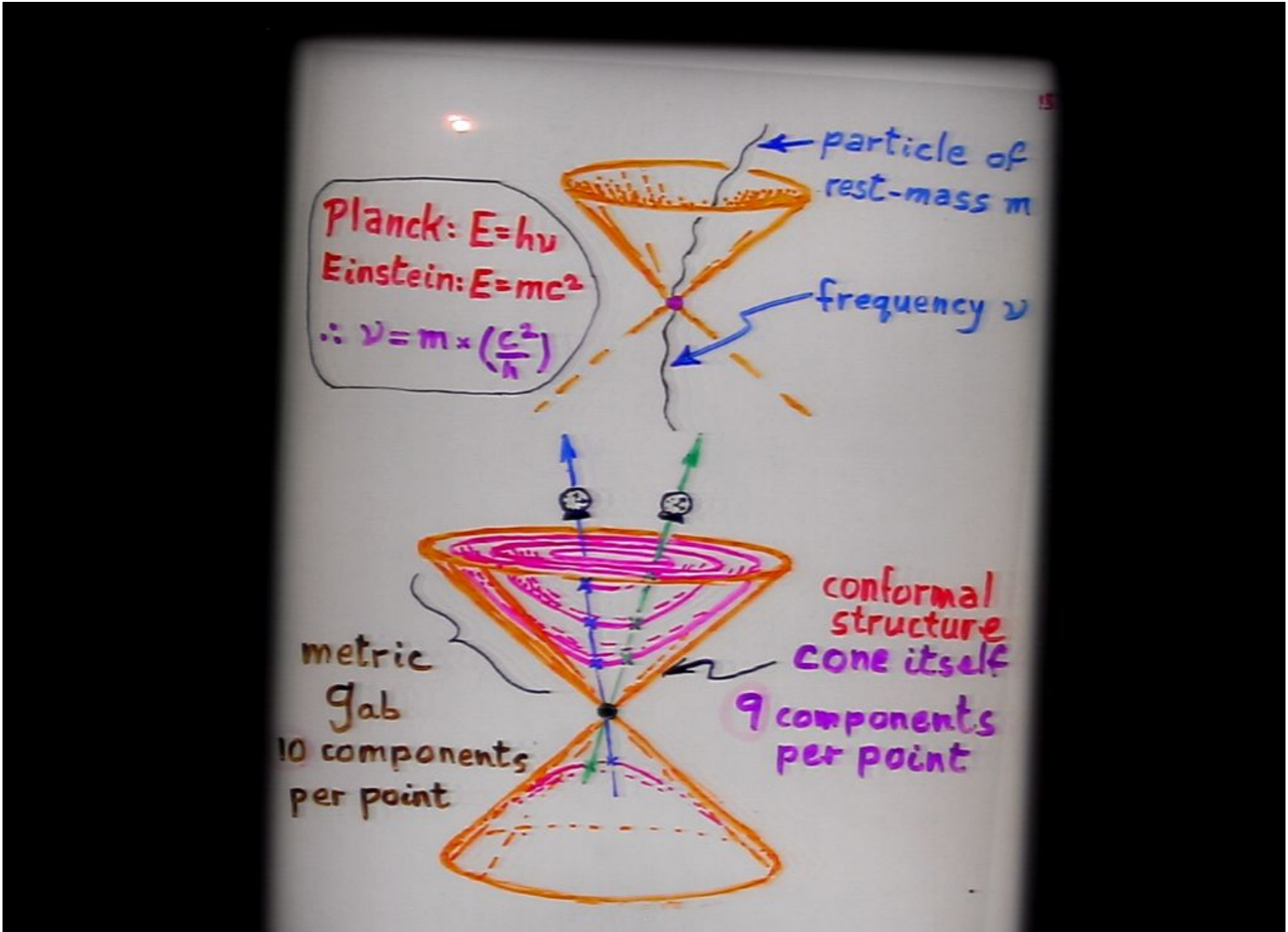
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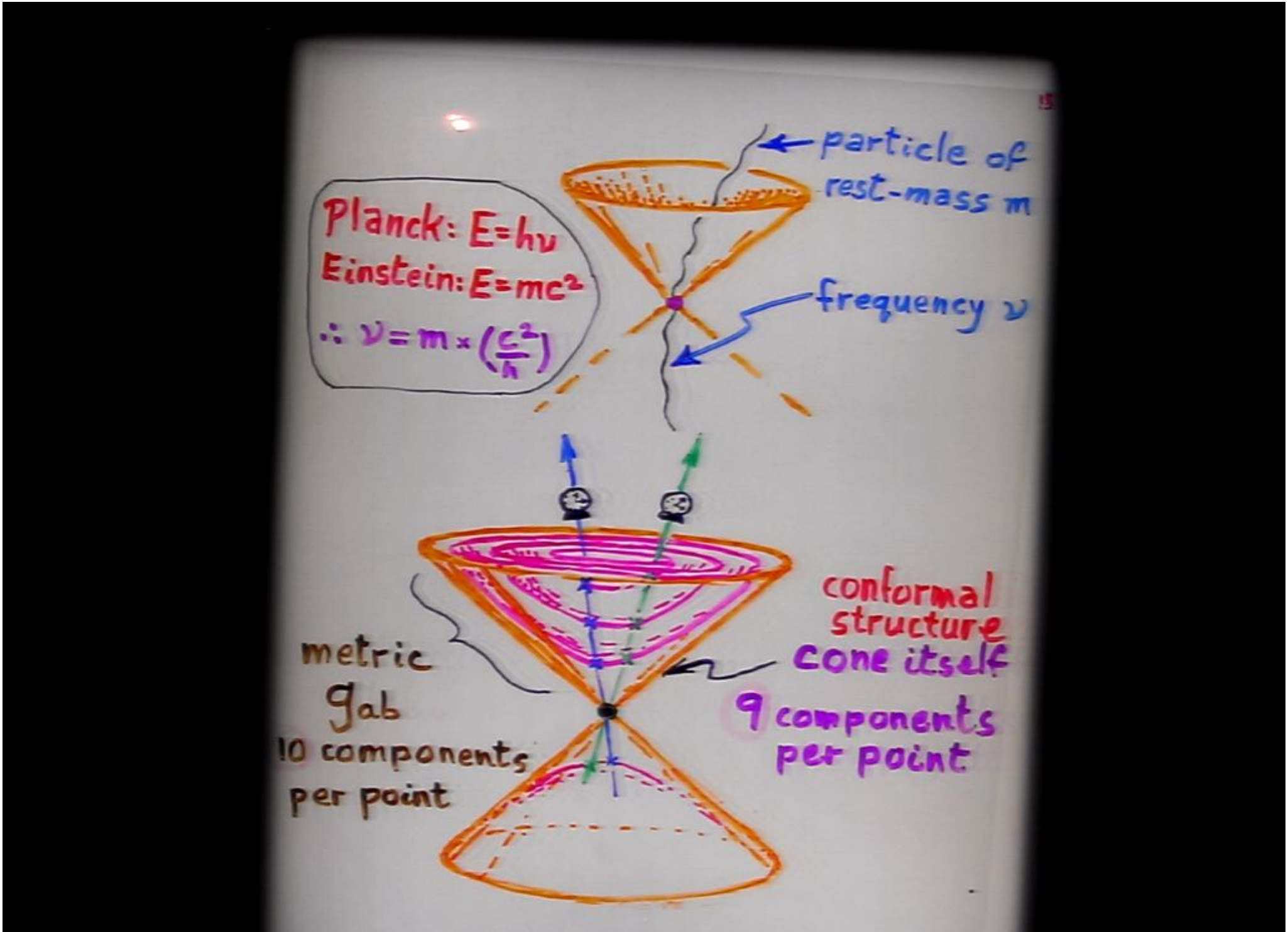
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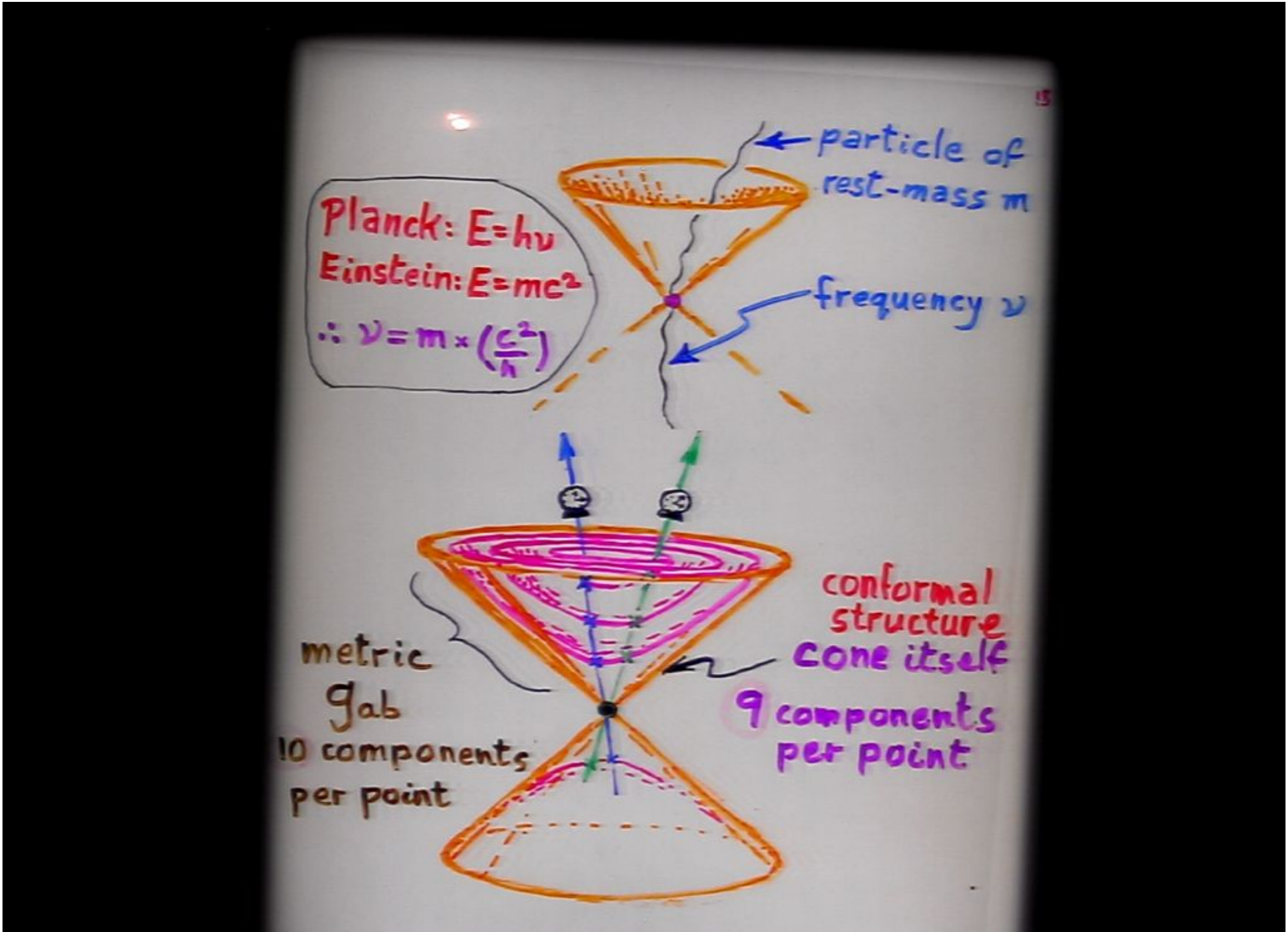
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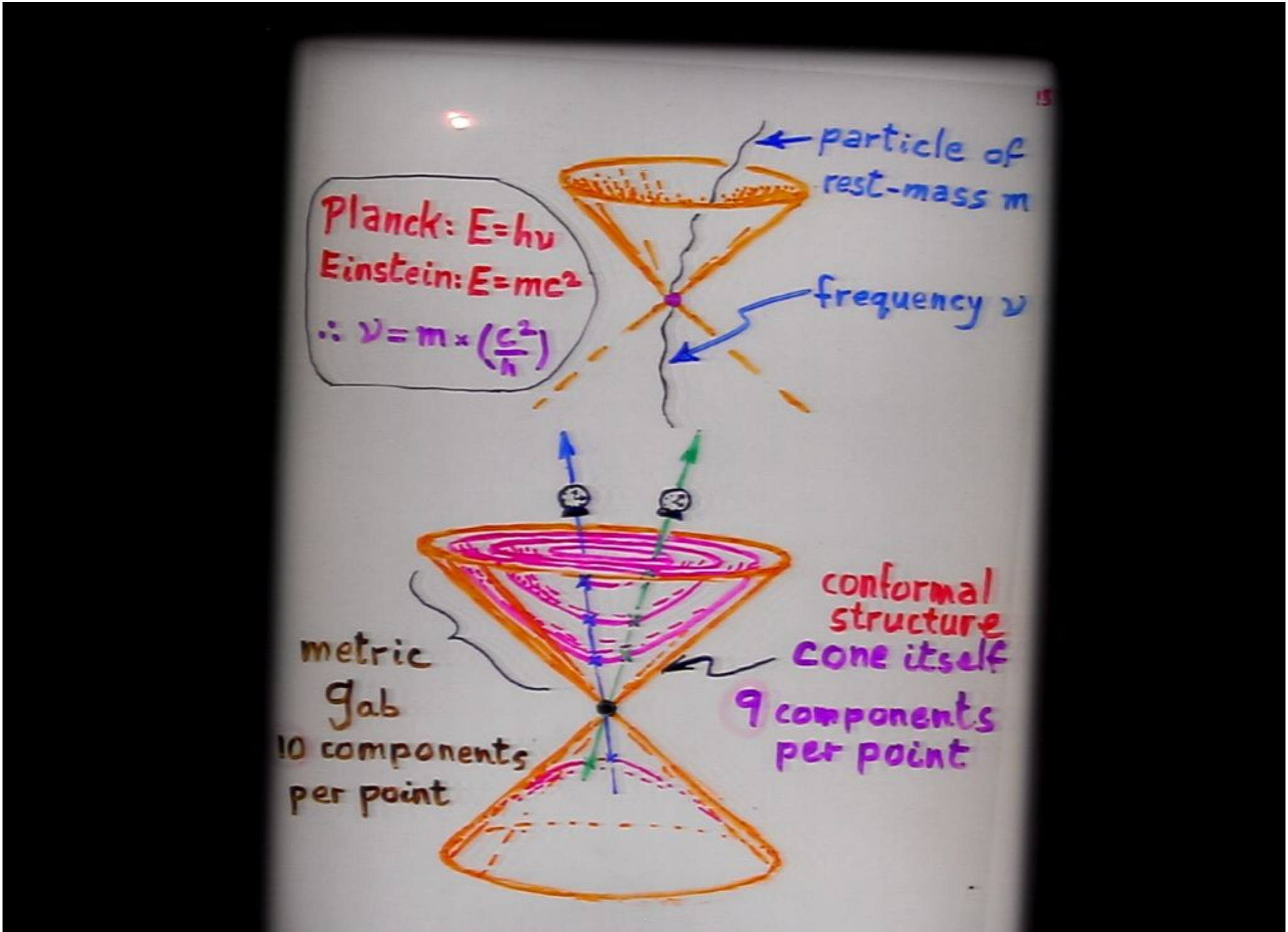
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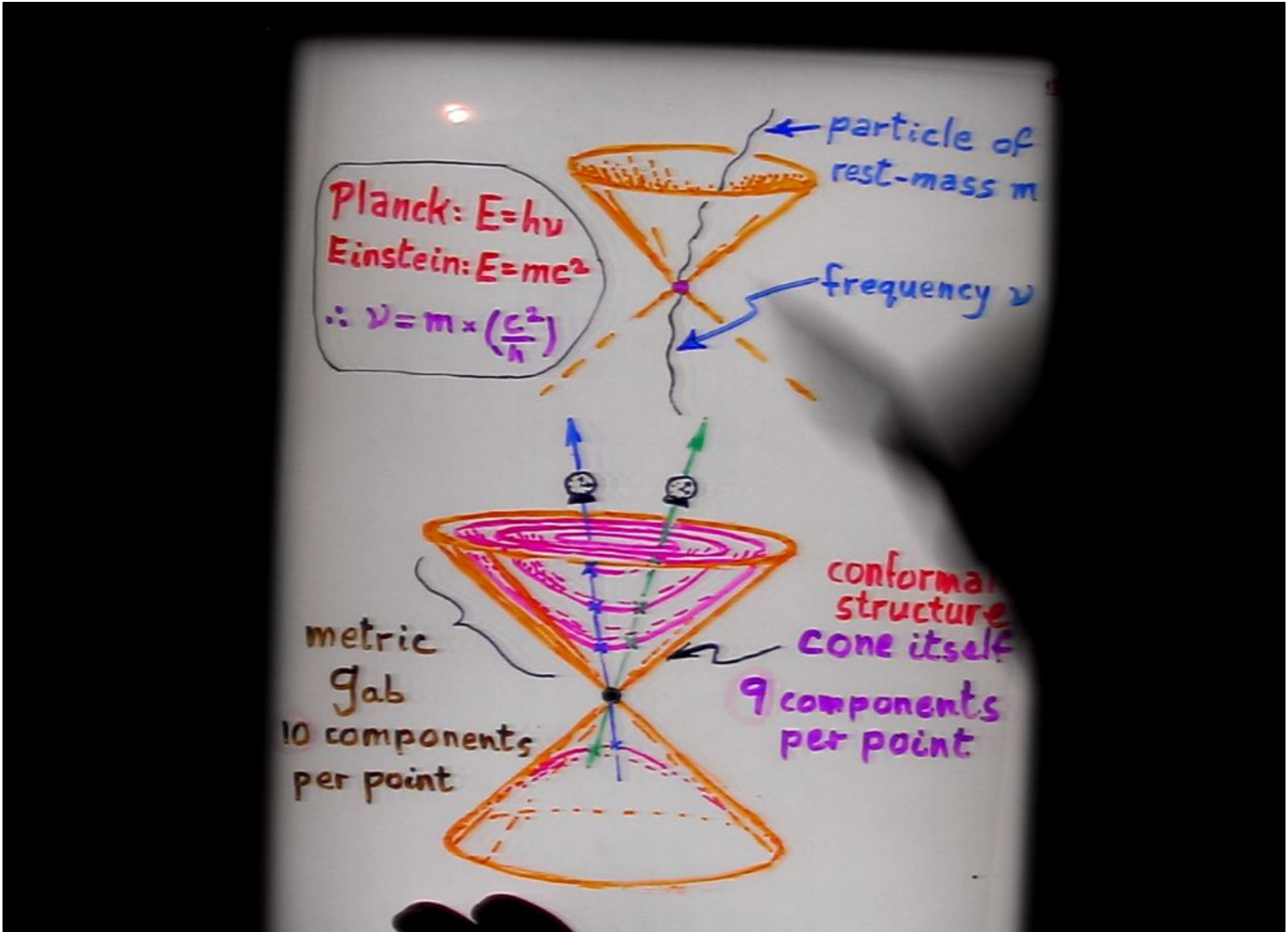
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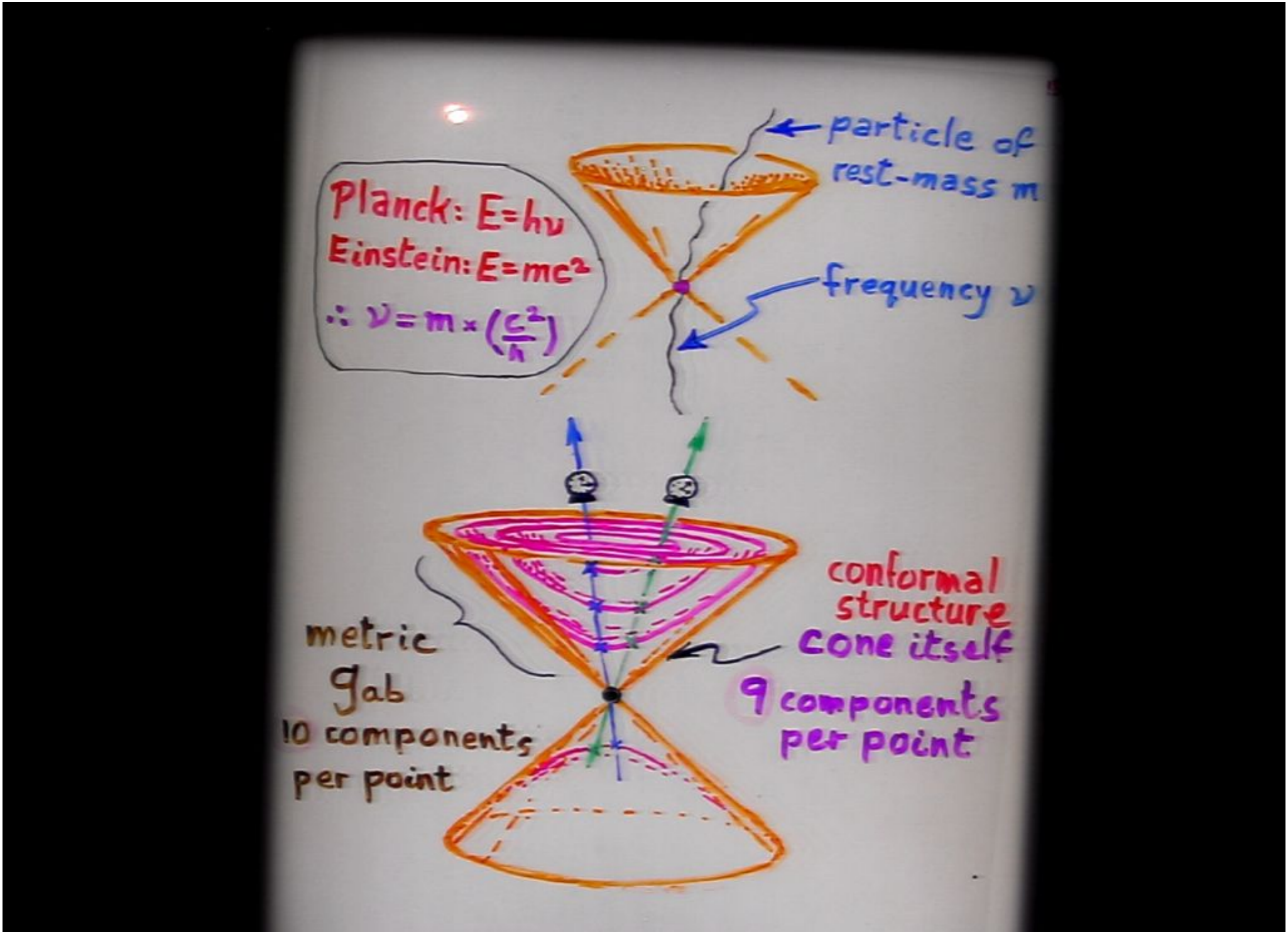
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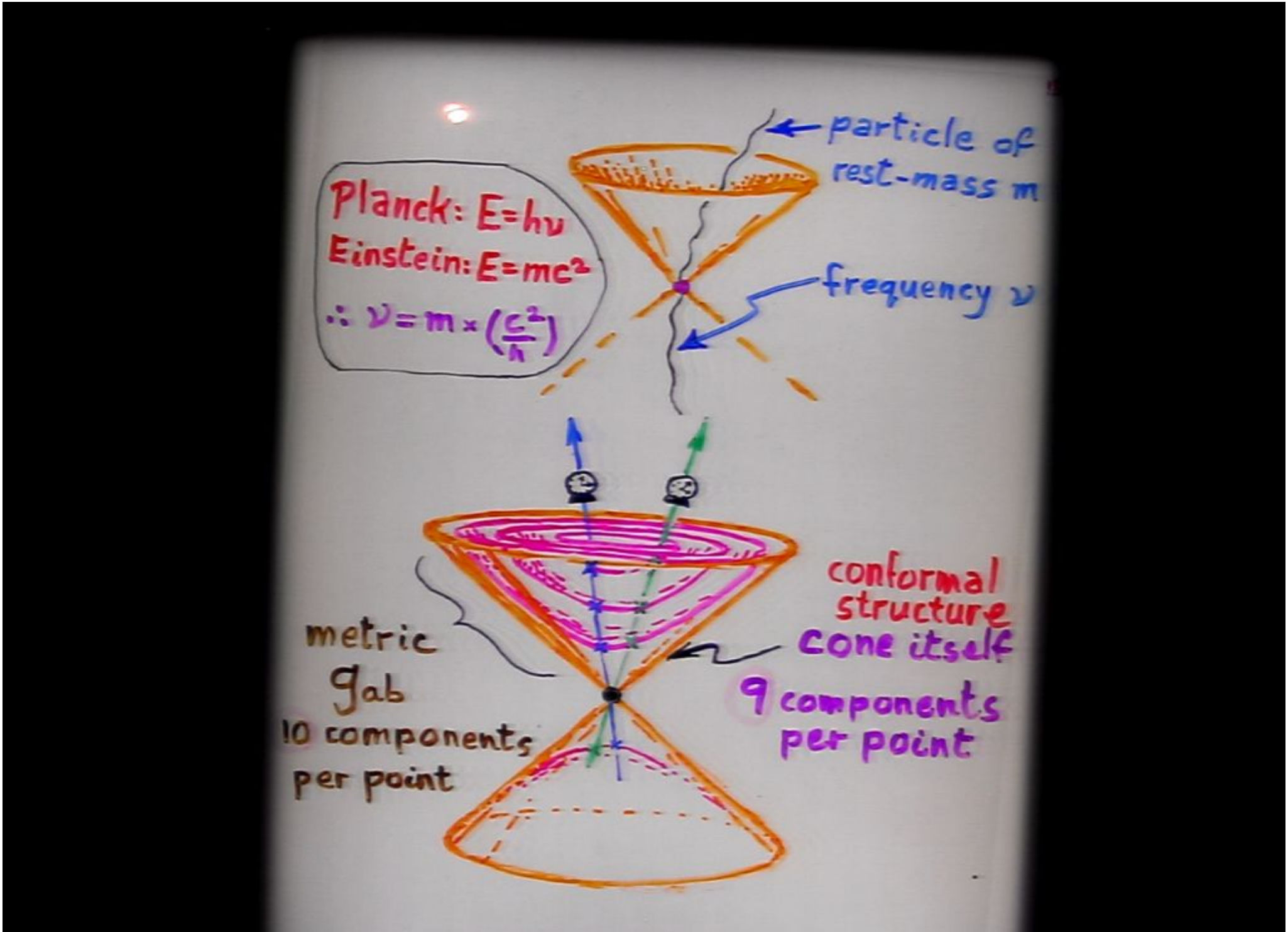
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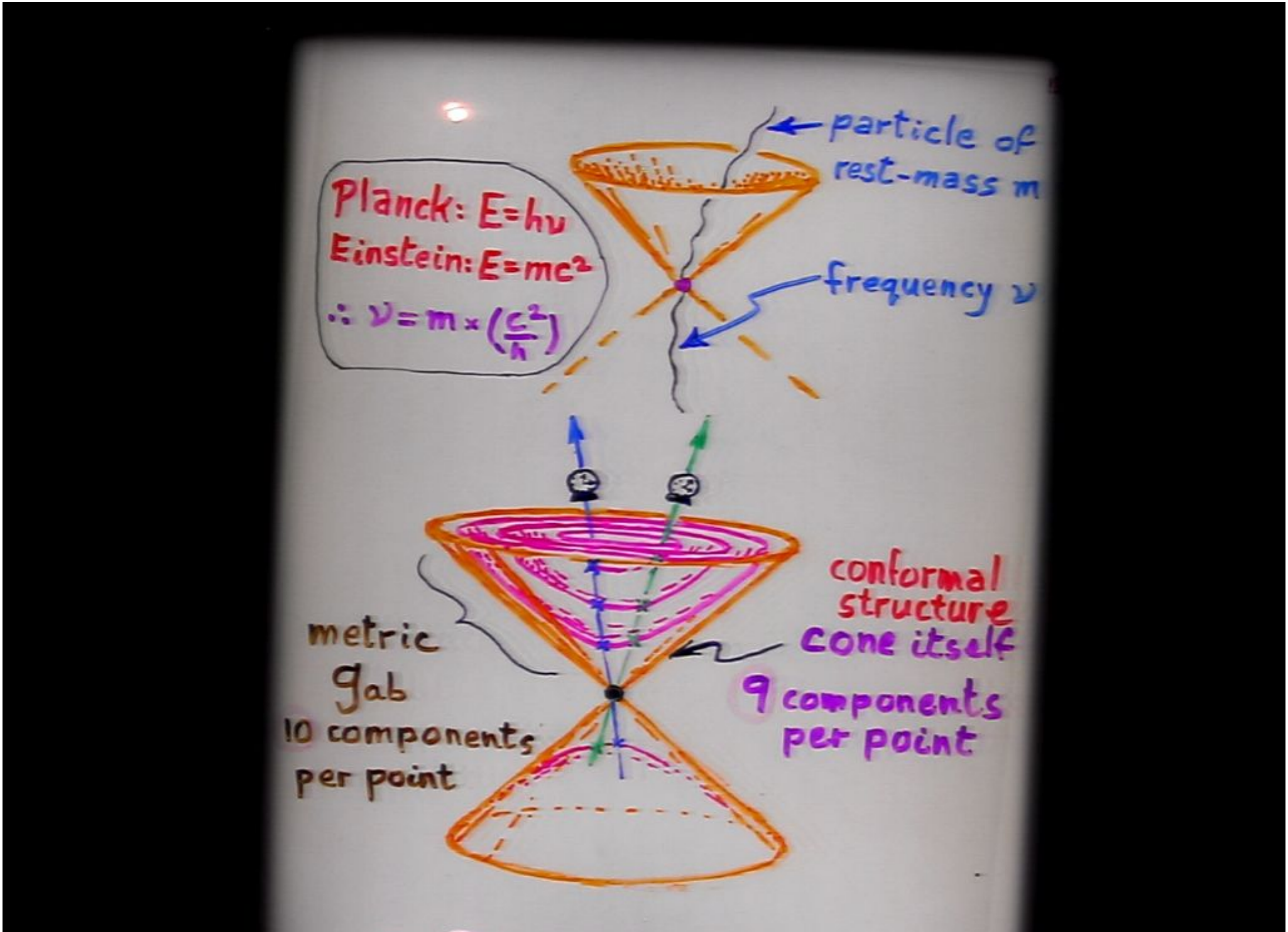
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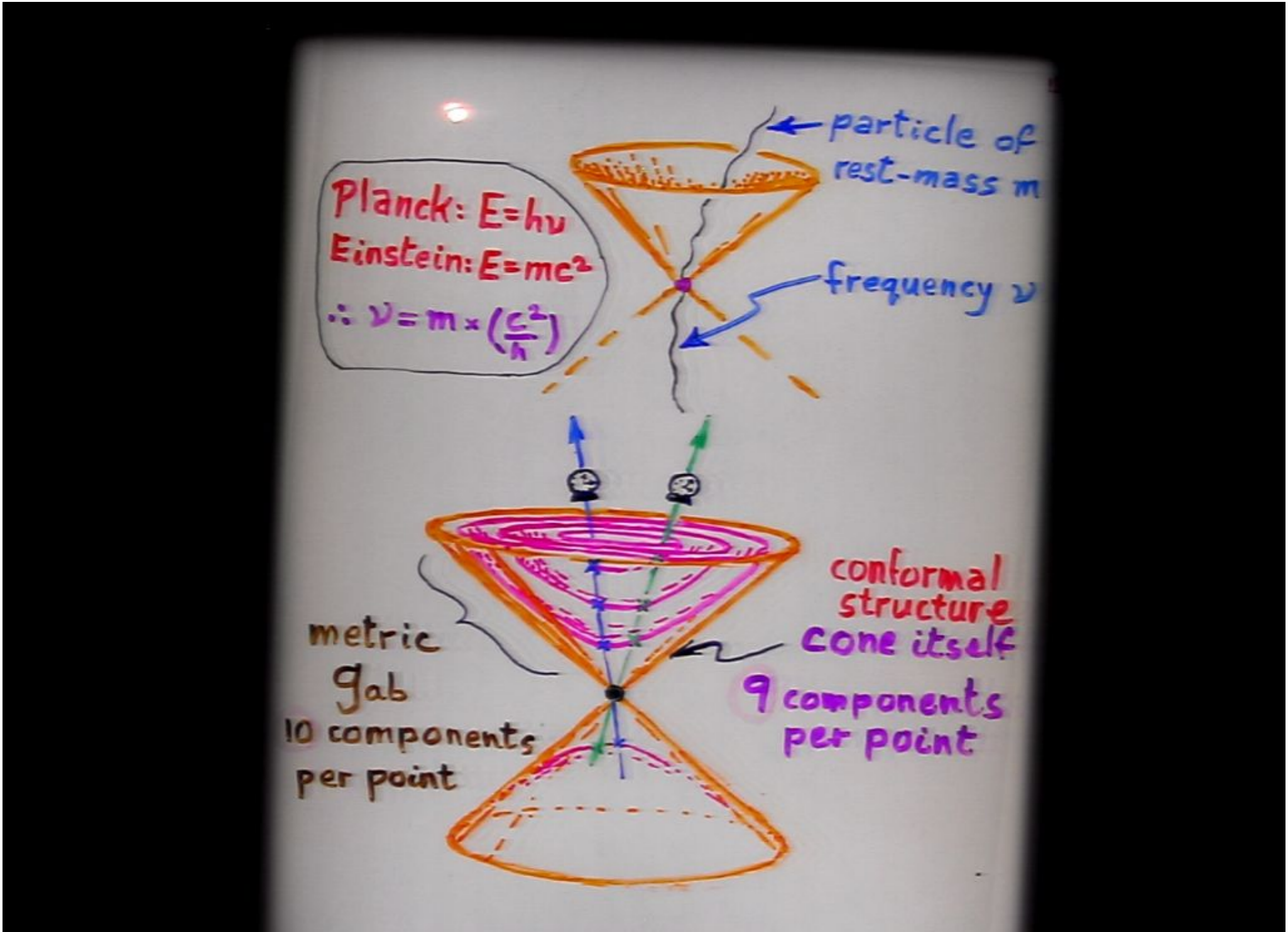
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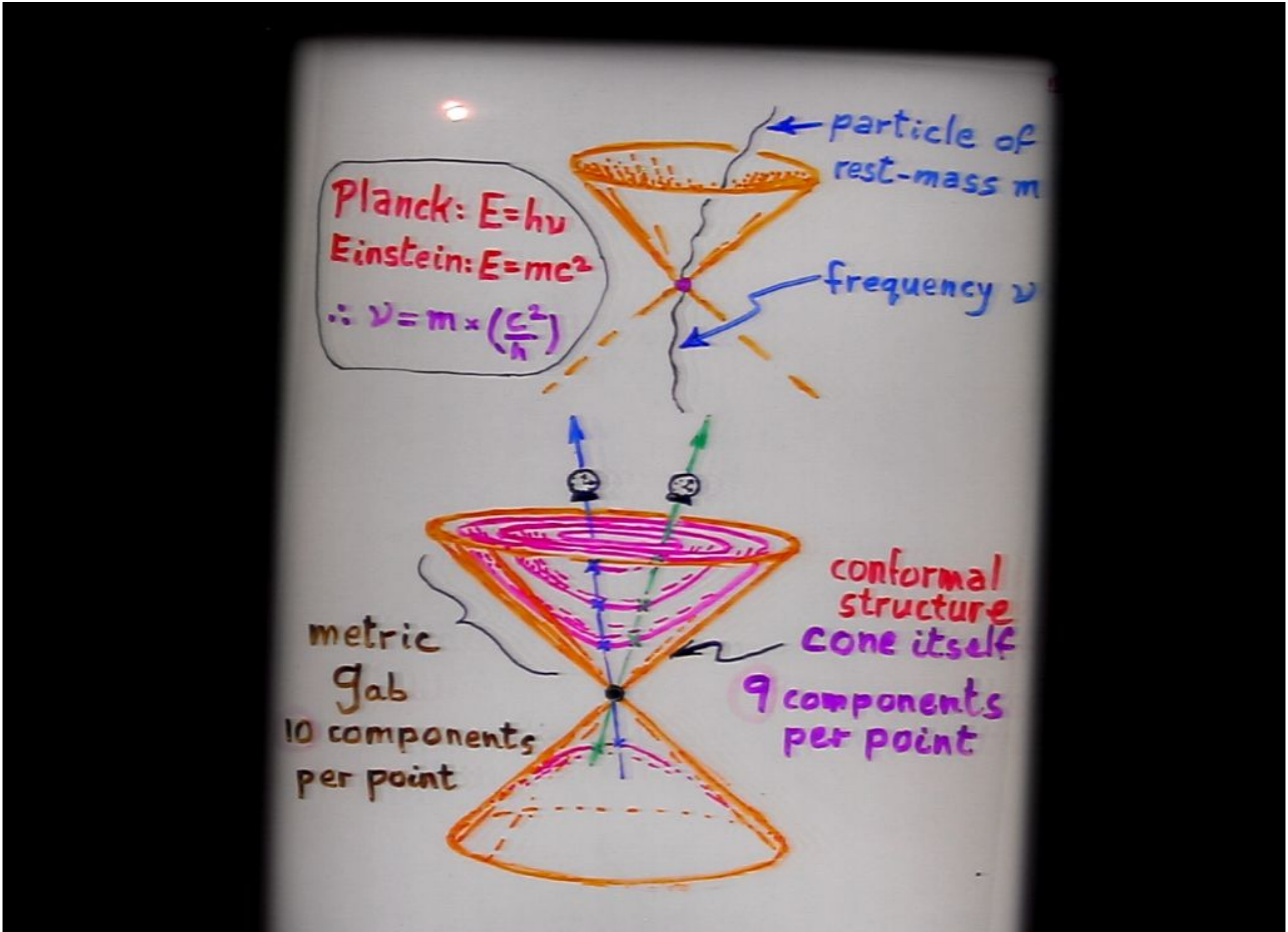
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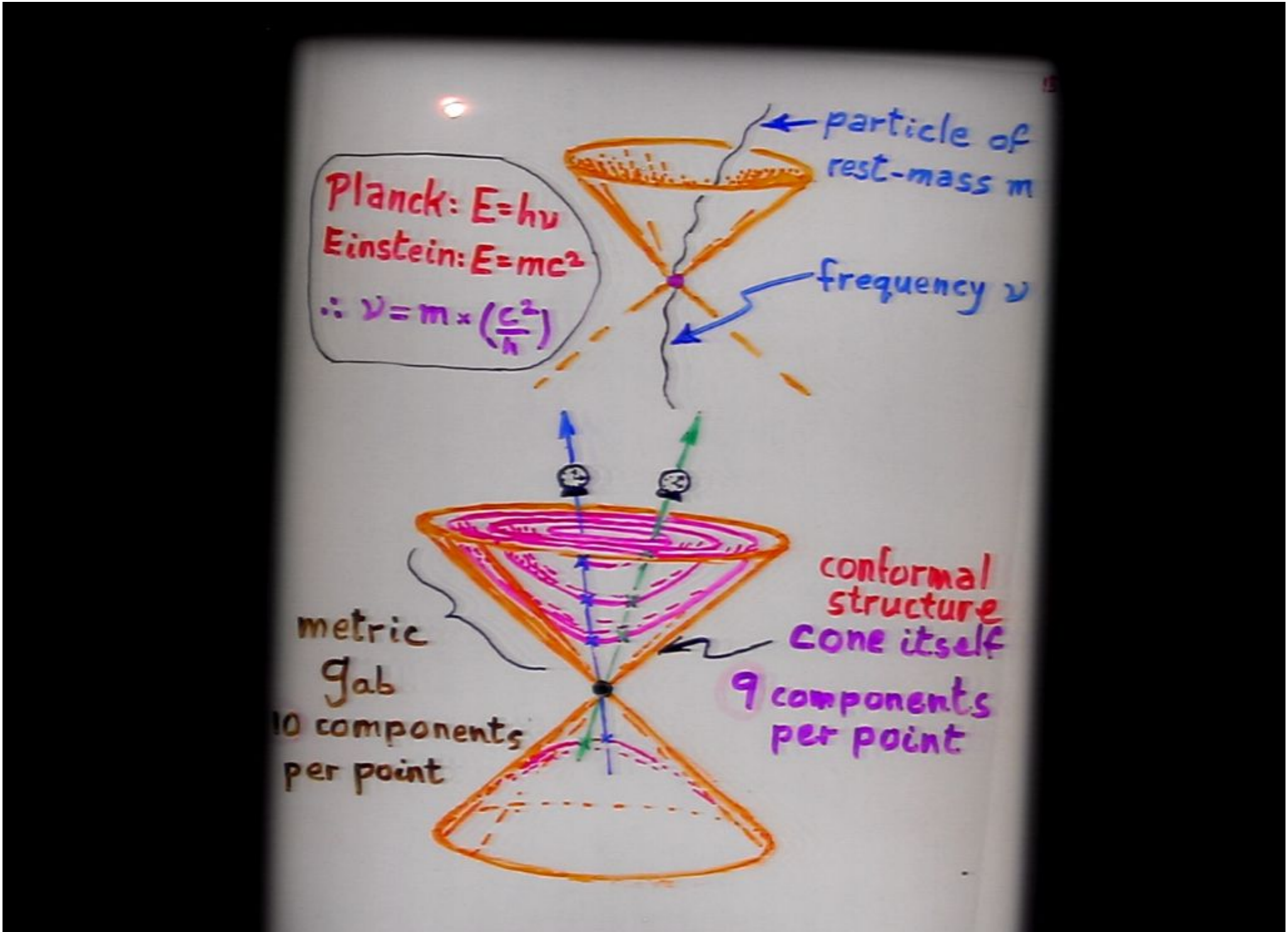
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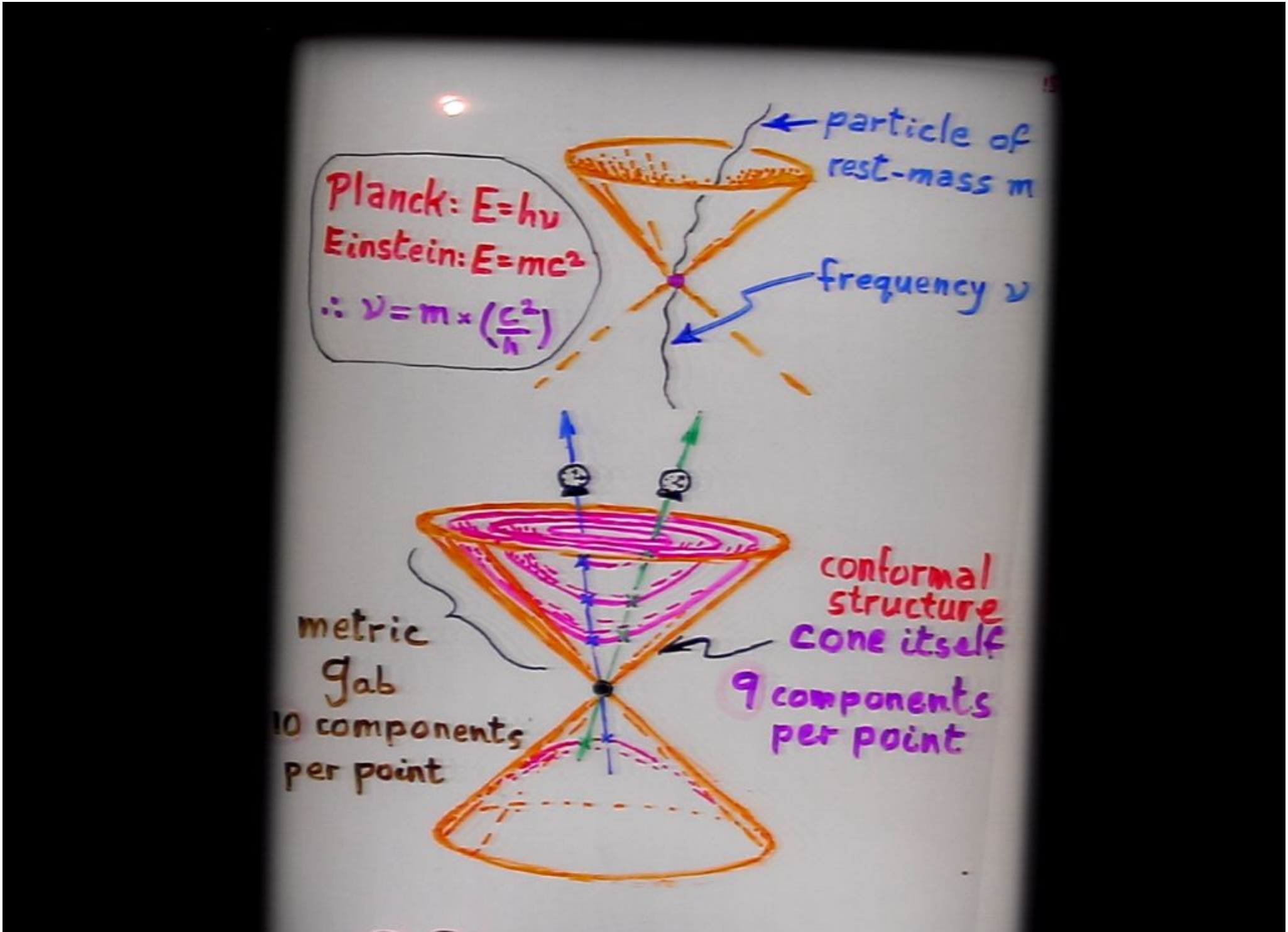
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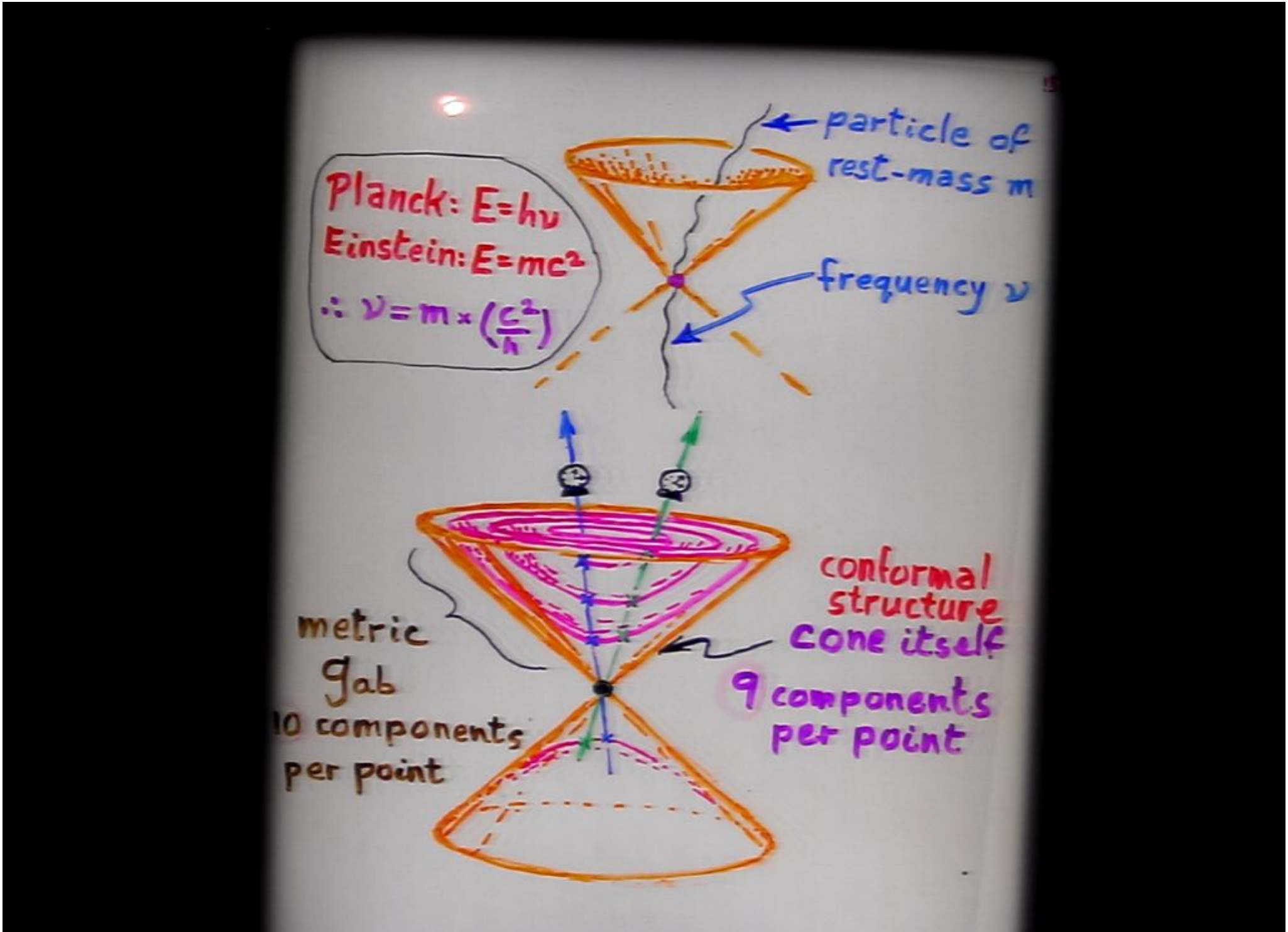
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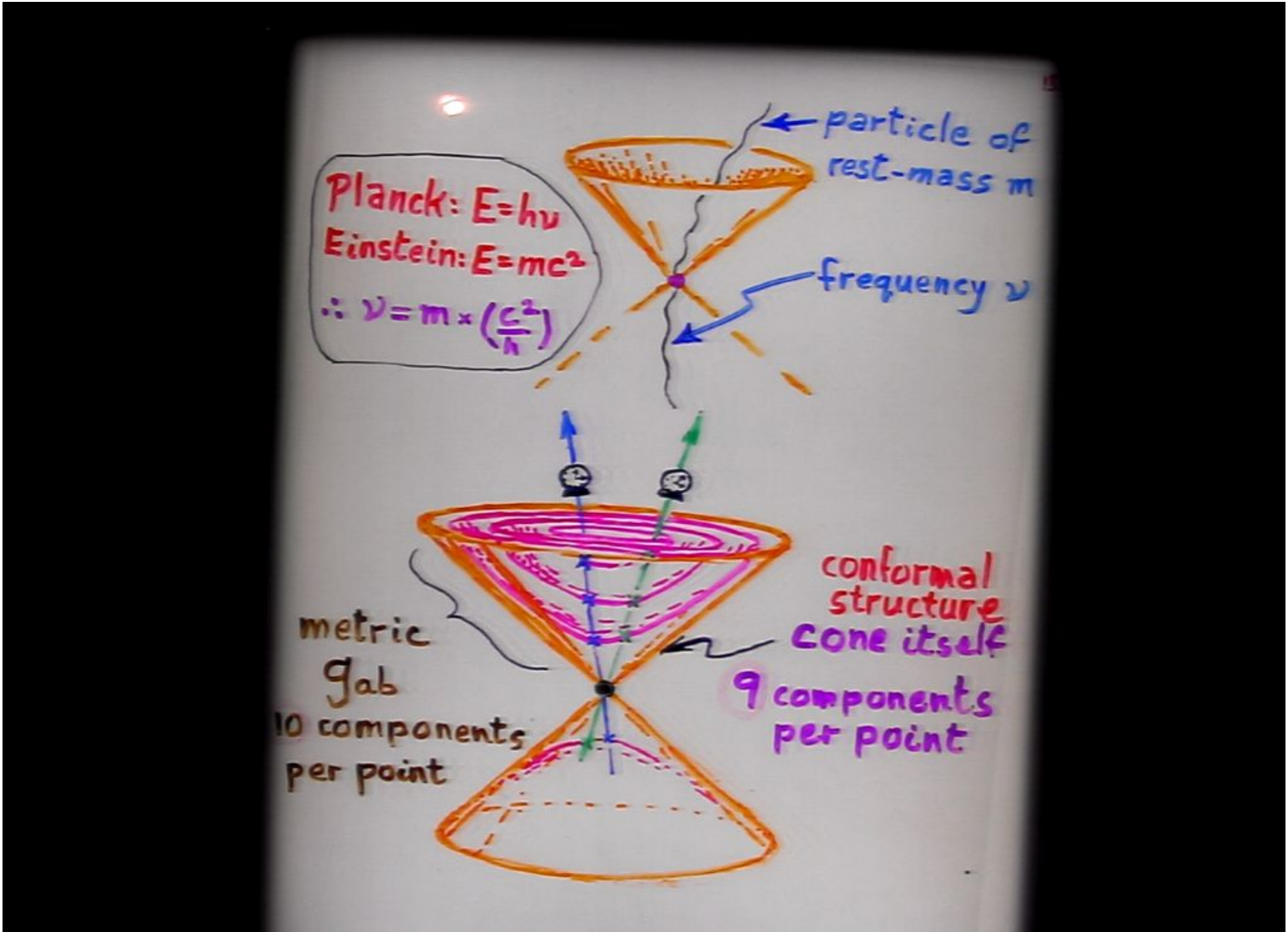
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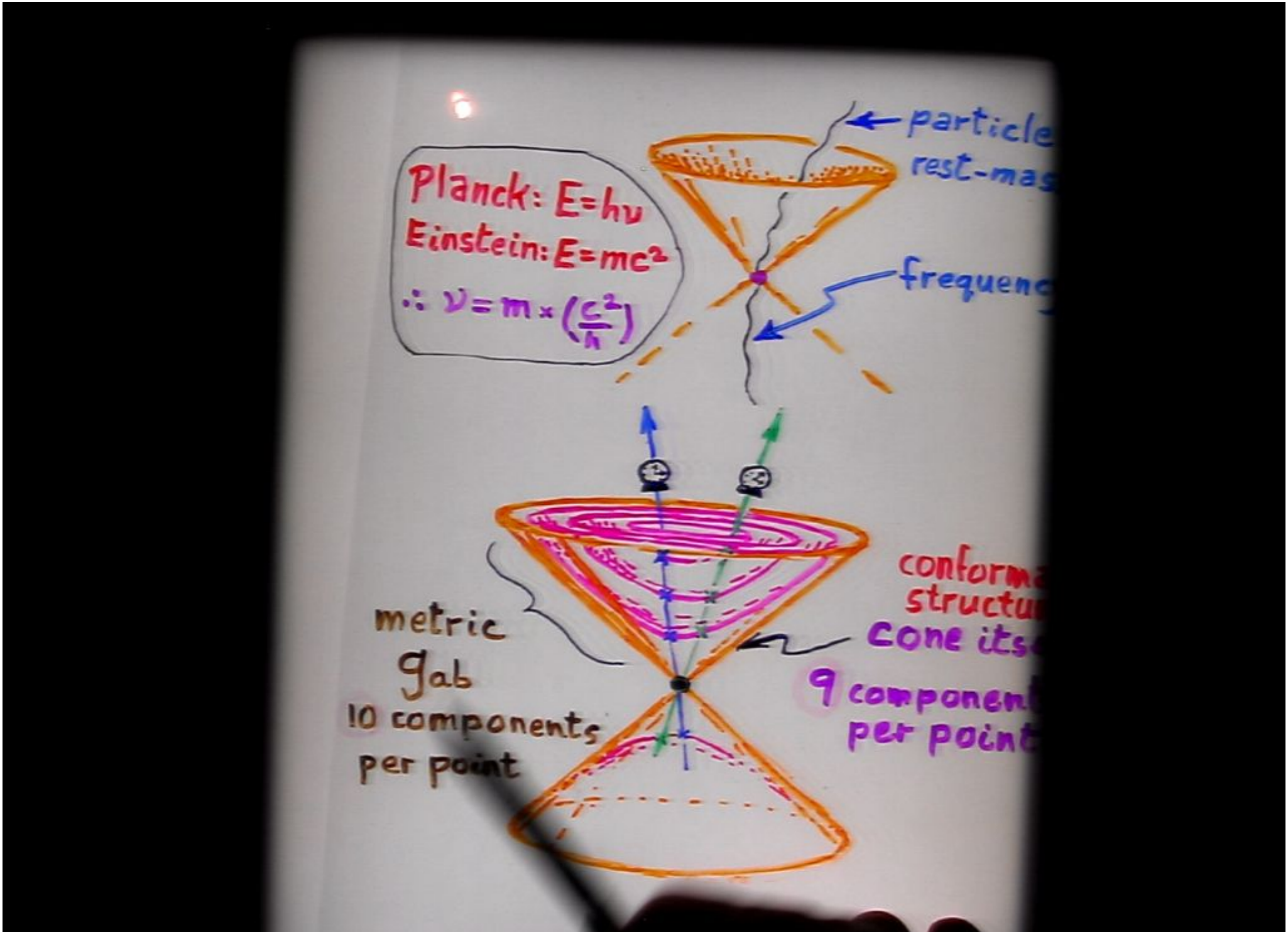
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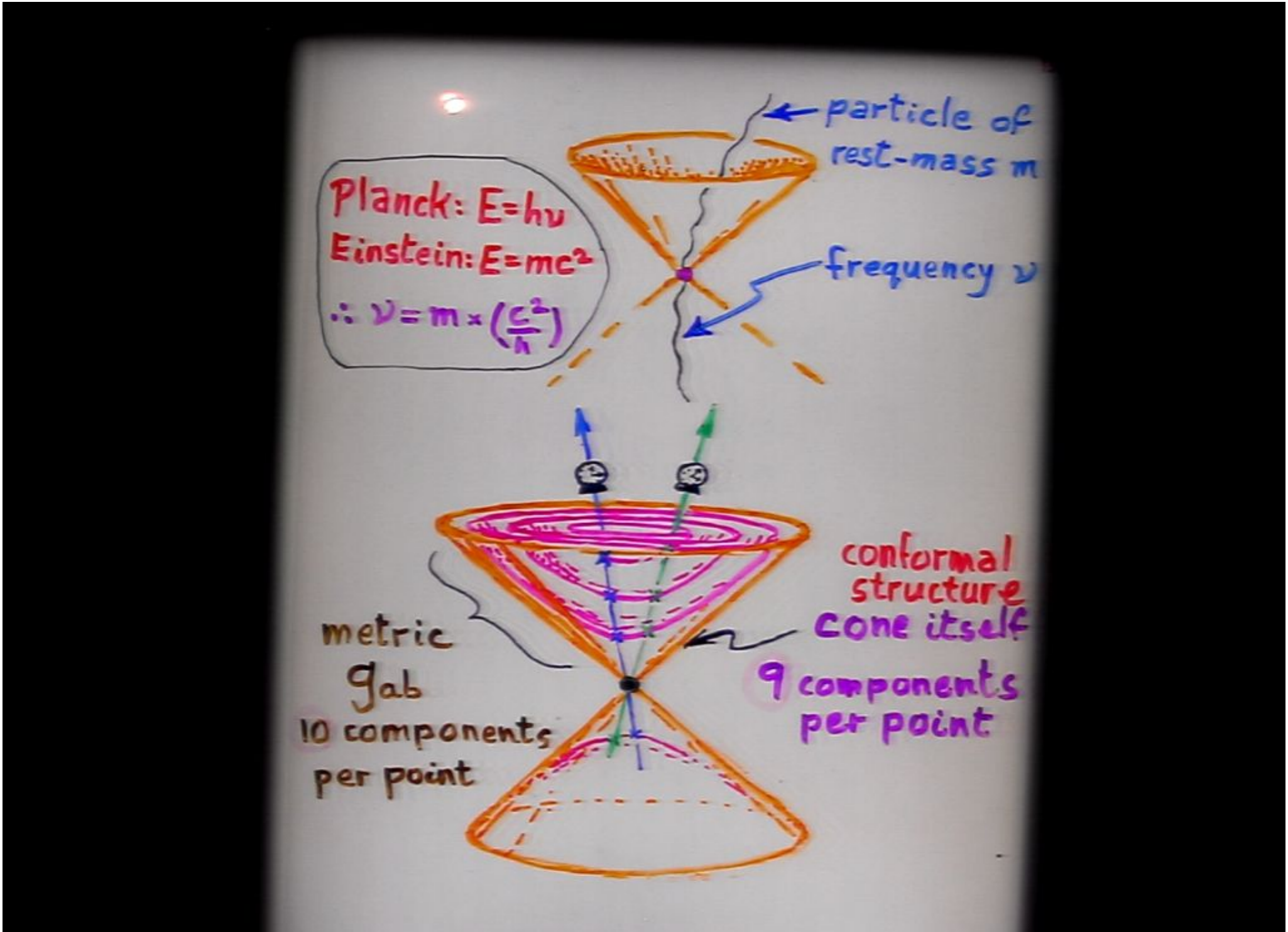
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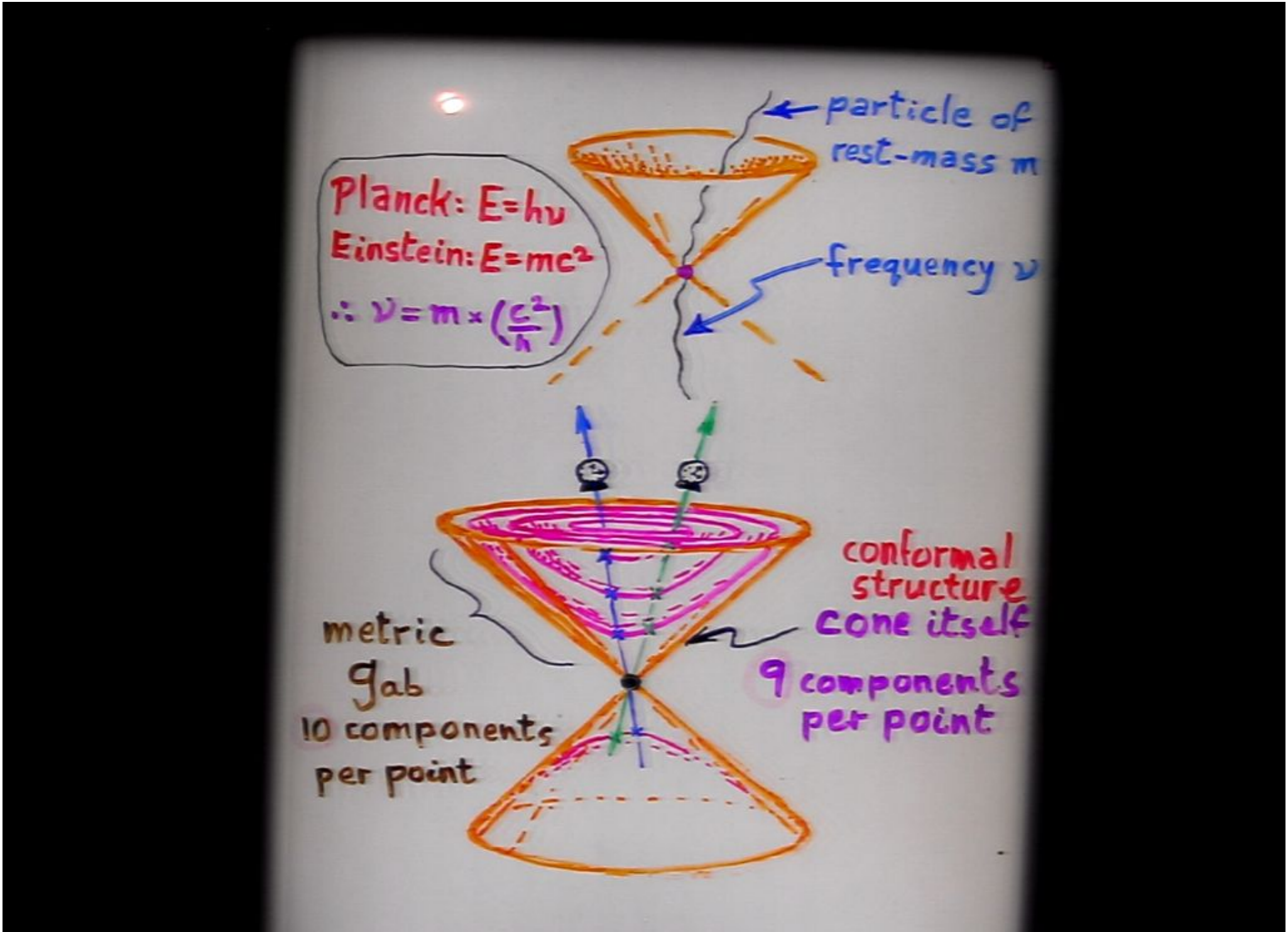
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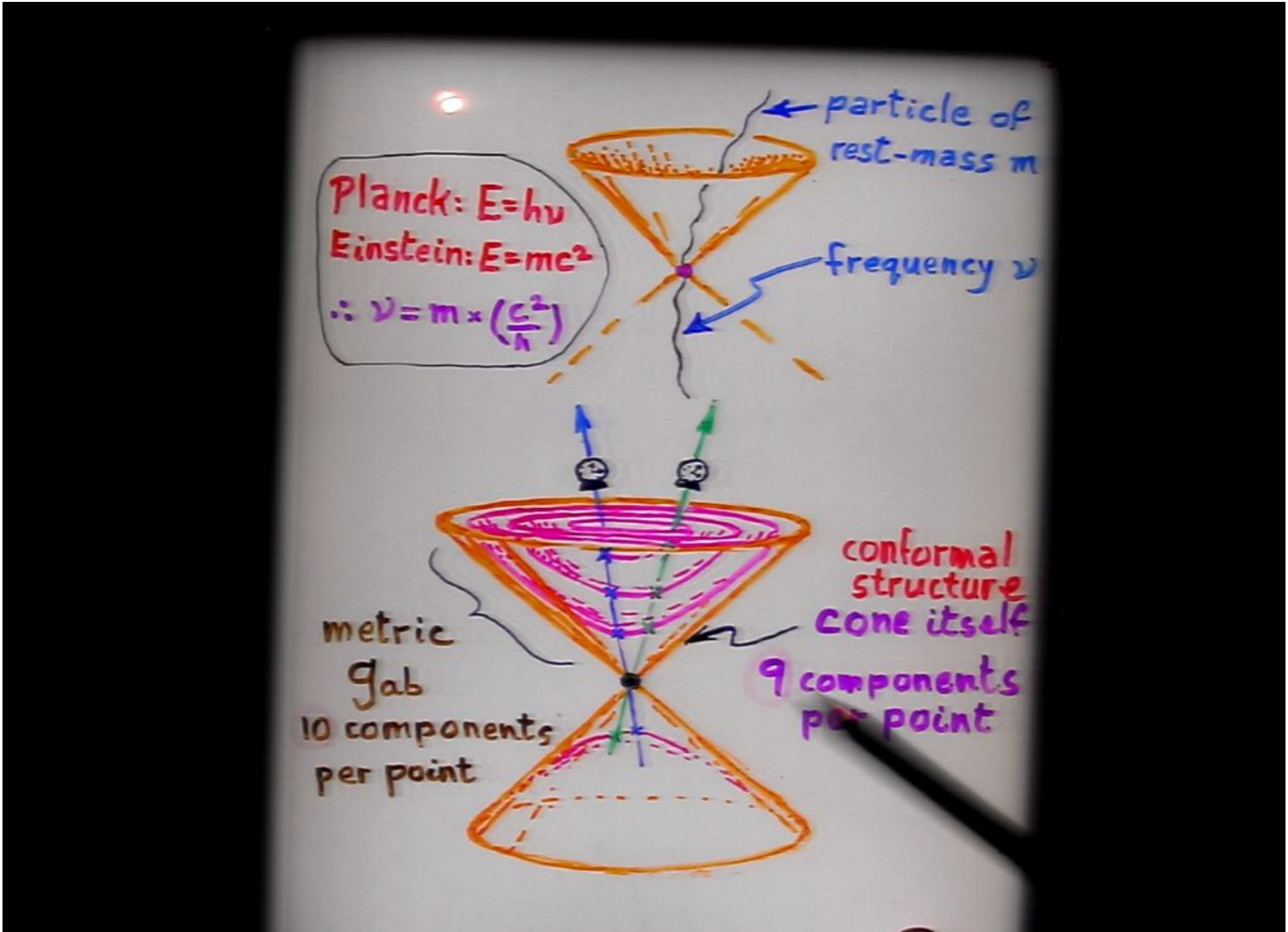
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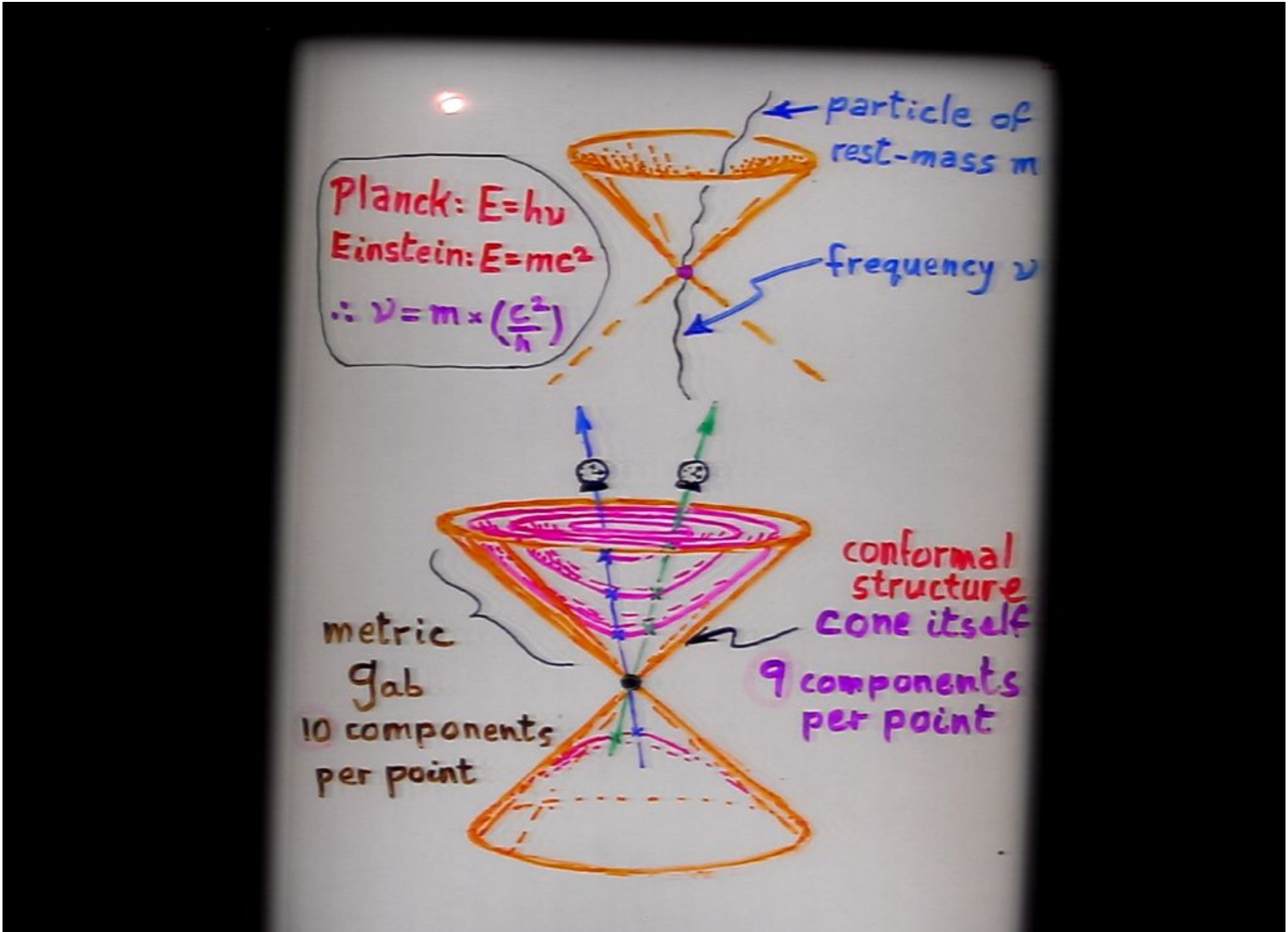
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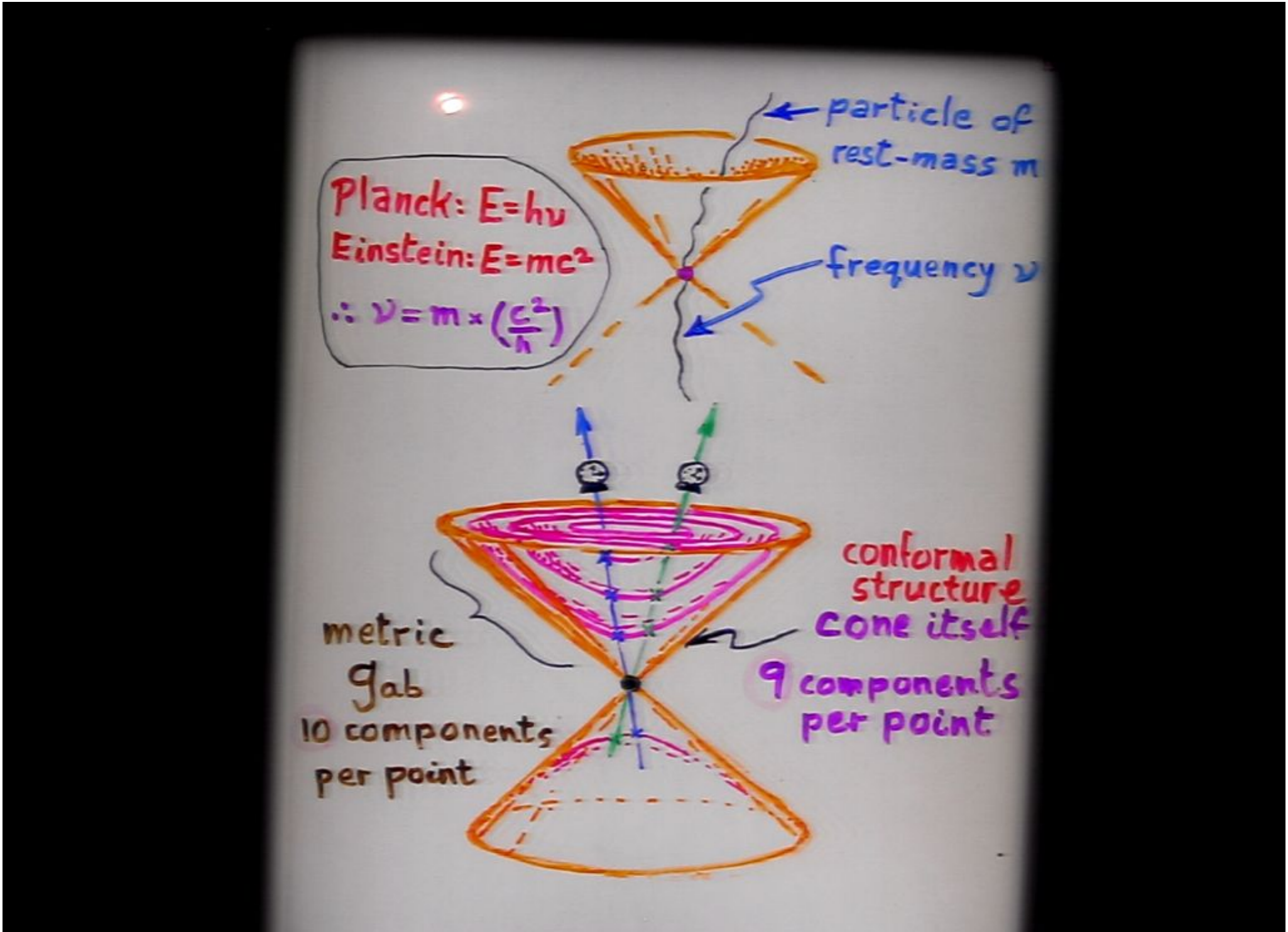
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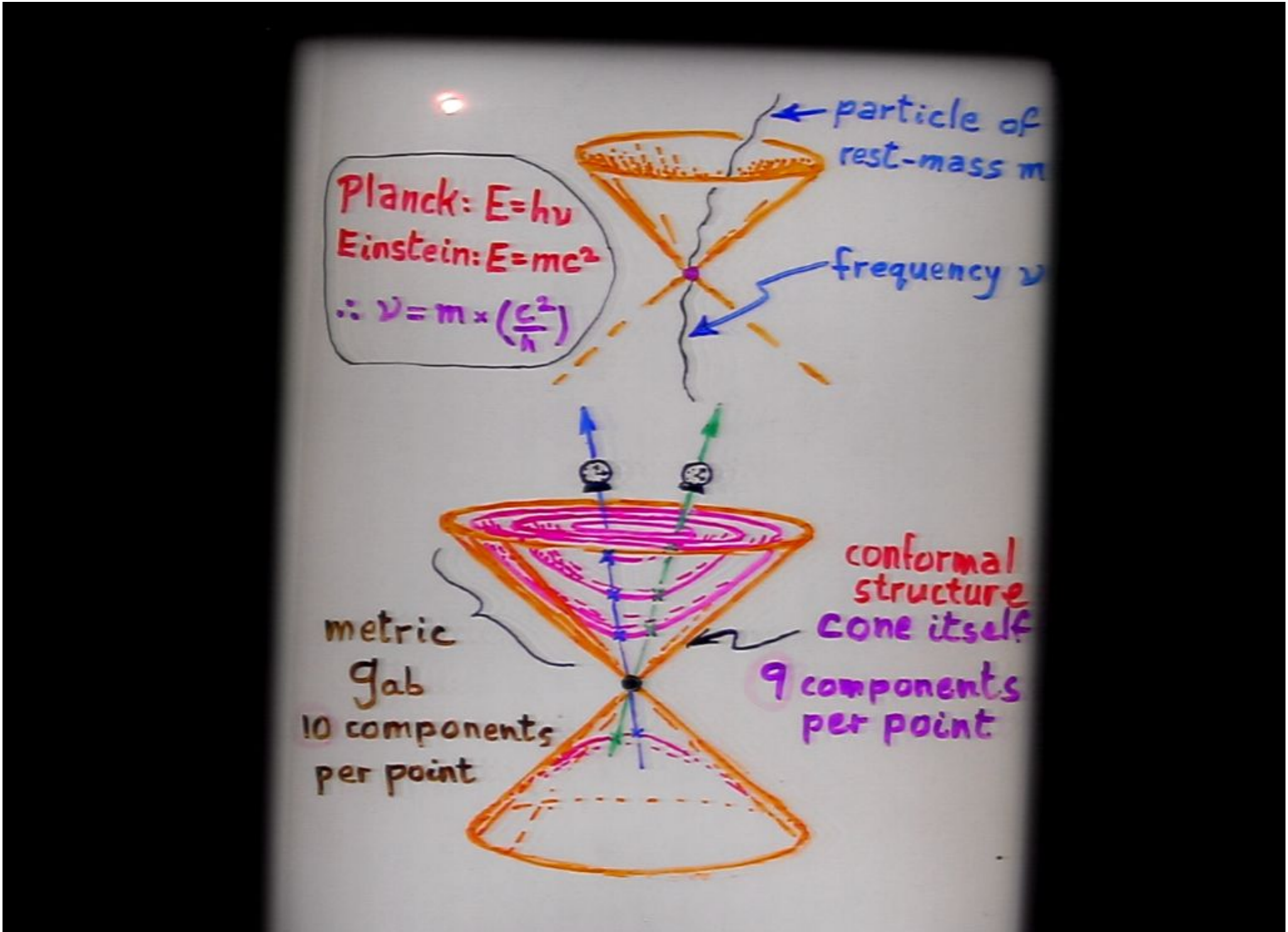
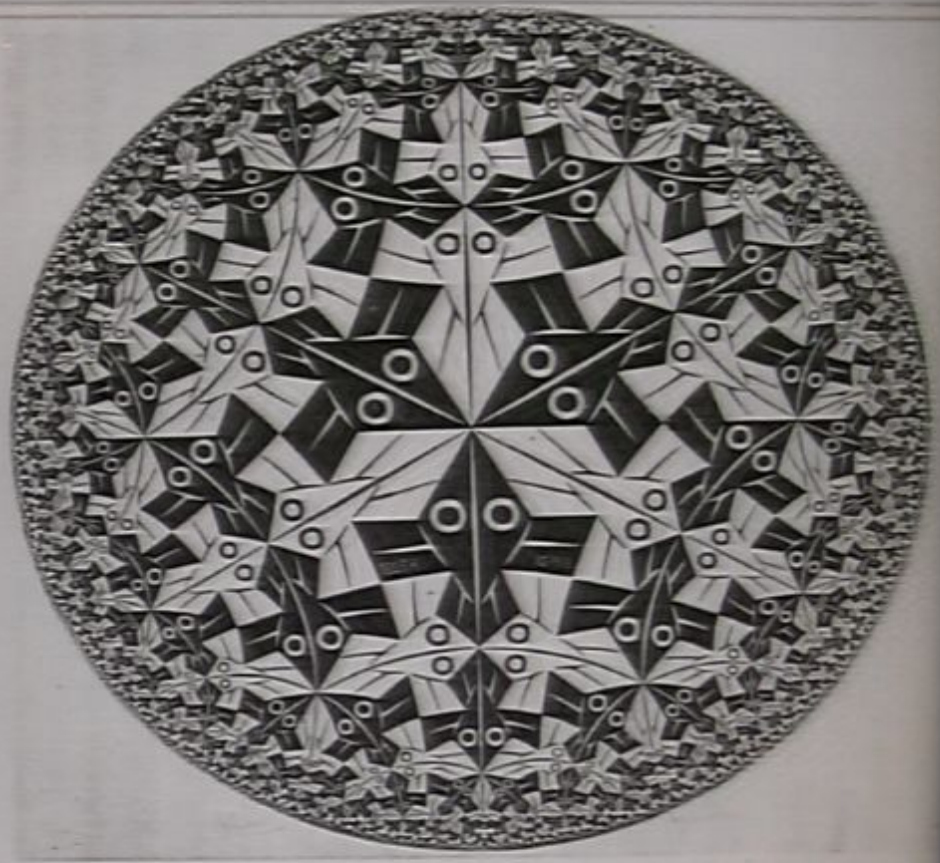
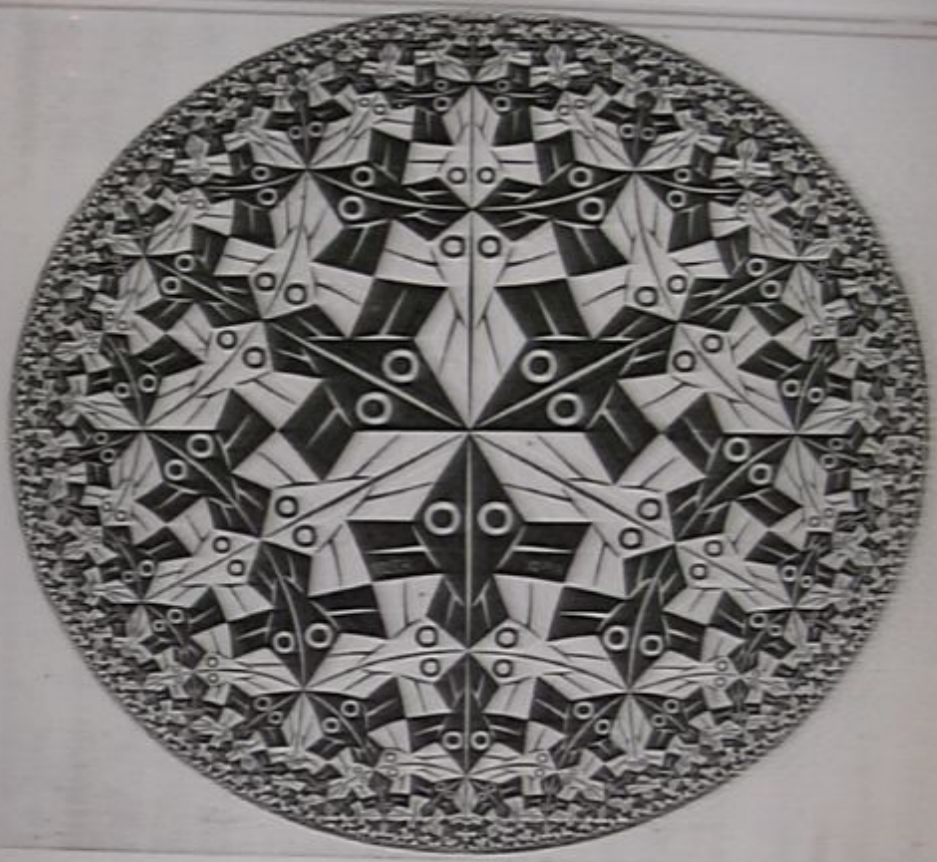

particle of
rest-mass m
Planck: $E=h\nu$
Einstein: $E=mc^2$
$\therefore \nu = m \times \left(\frac{c^2}{h}\right)$
frequency ν
conformal
structure
cone itself
9 components
per point
metric
g_{ab}
10 components
per point



M. C. Escher *Circle Limit I*

Hyperbolic geome

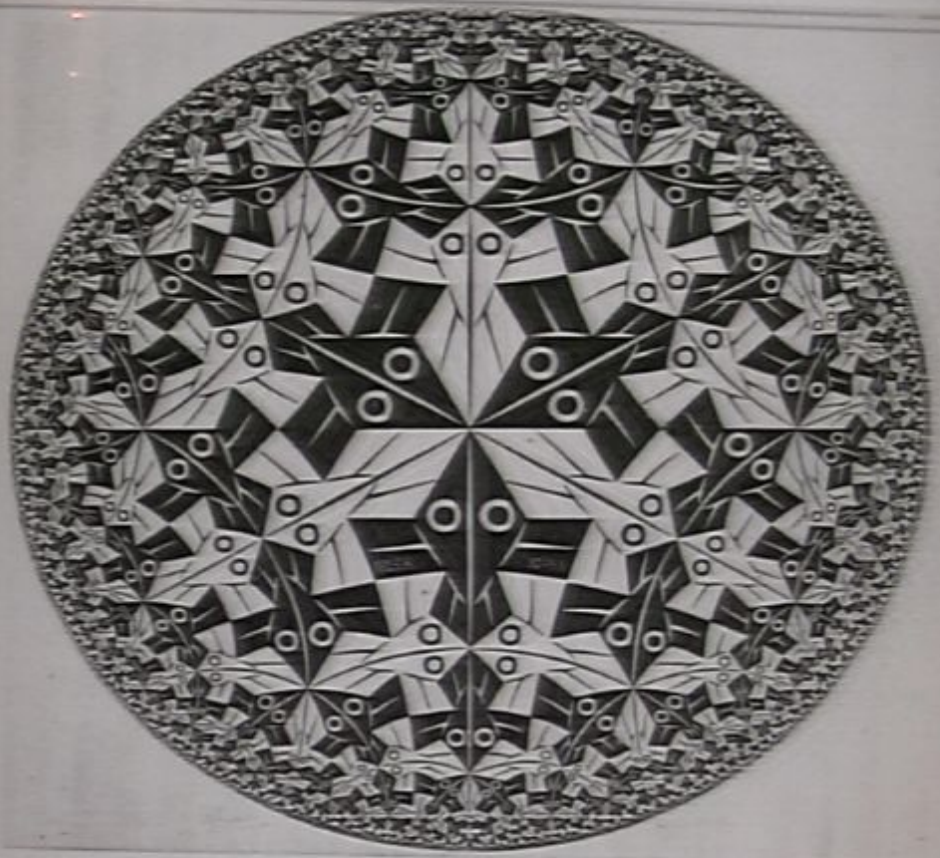
Saccheri
Lambert
Gauss
Lobachewski
Bolai
Beltrami
Poincaré



M. C. Escher *Circle Limit I*

Hyperbolic geometry

- Saccheri
- Lambert
- Gauss
- Lobachewski
- Bolai
- Beltrami
- Poincaré
- .....



M. C. Escher *Circle Limit I*

Hyperbolic geometry

- Saccheri
- Lambert
- Gauss
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- .....



M. C. Escher *Circle Limit I*

Hyperbolic geometry

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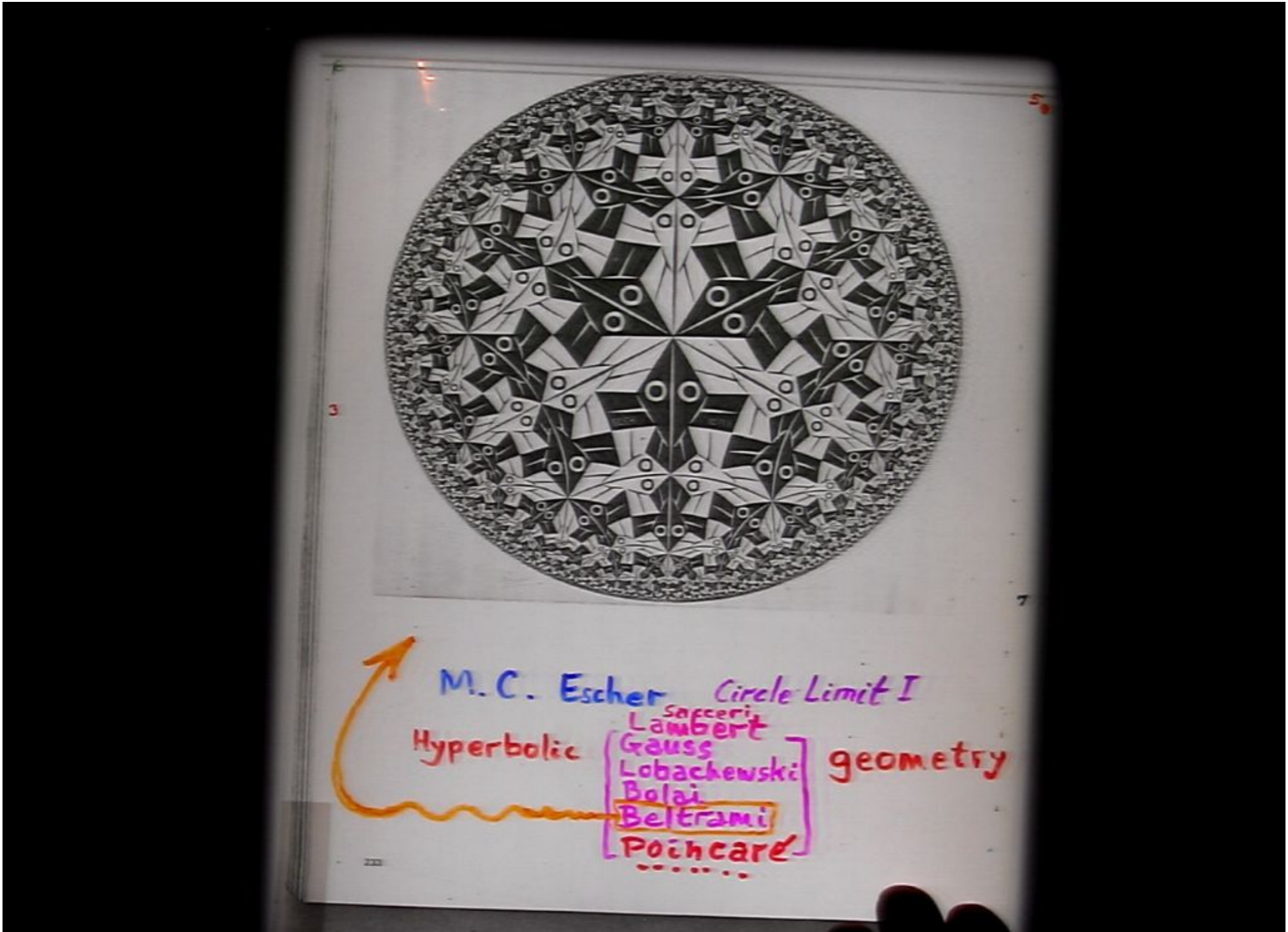
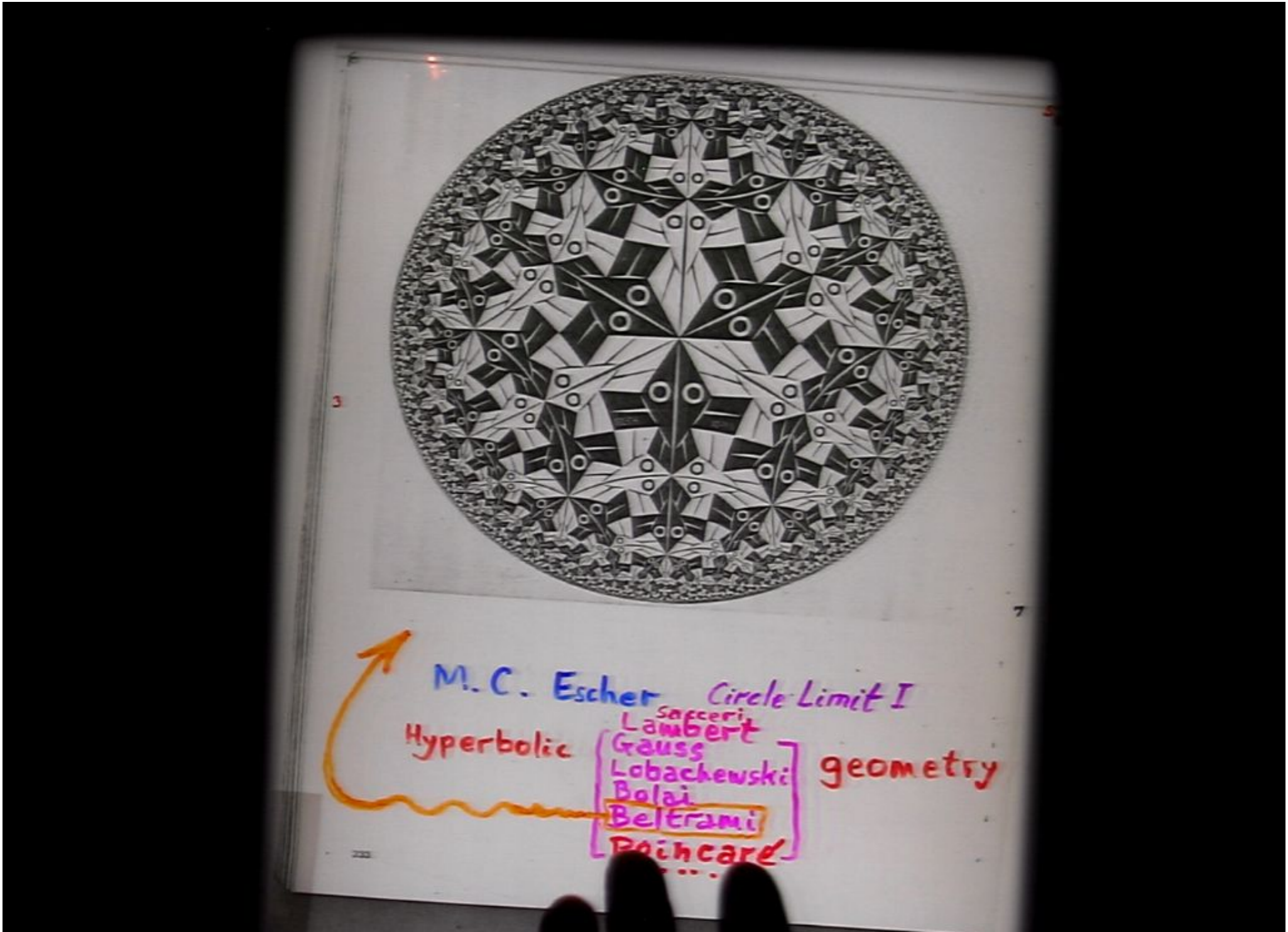

M. C. Escher
Circle Limit I
Hyperbolic
Saccheri
Lambert
Gauss
Lobachewski
Bolai
Beltrami
Poincaré
geometry



M. C. Escher *Circle Limit I*

Hyperbolic [Saccheri, Lambert, Gauss, Lobachewski, Bolai, Beltrami, Poincaré .....] geometry


M. C. Escher
Circle Limit I
Hyperbolic
Saccheri
Lambert
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Bolai
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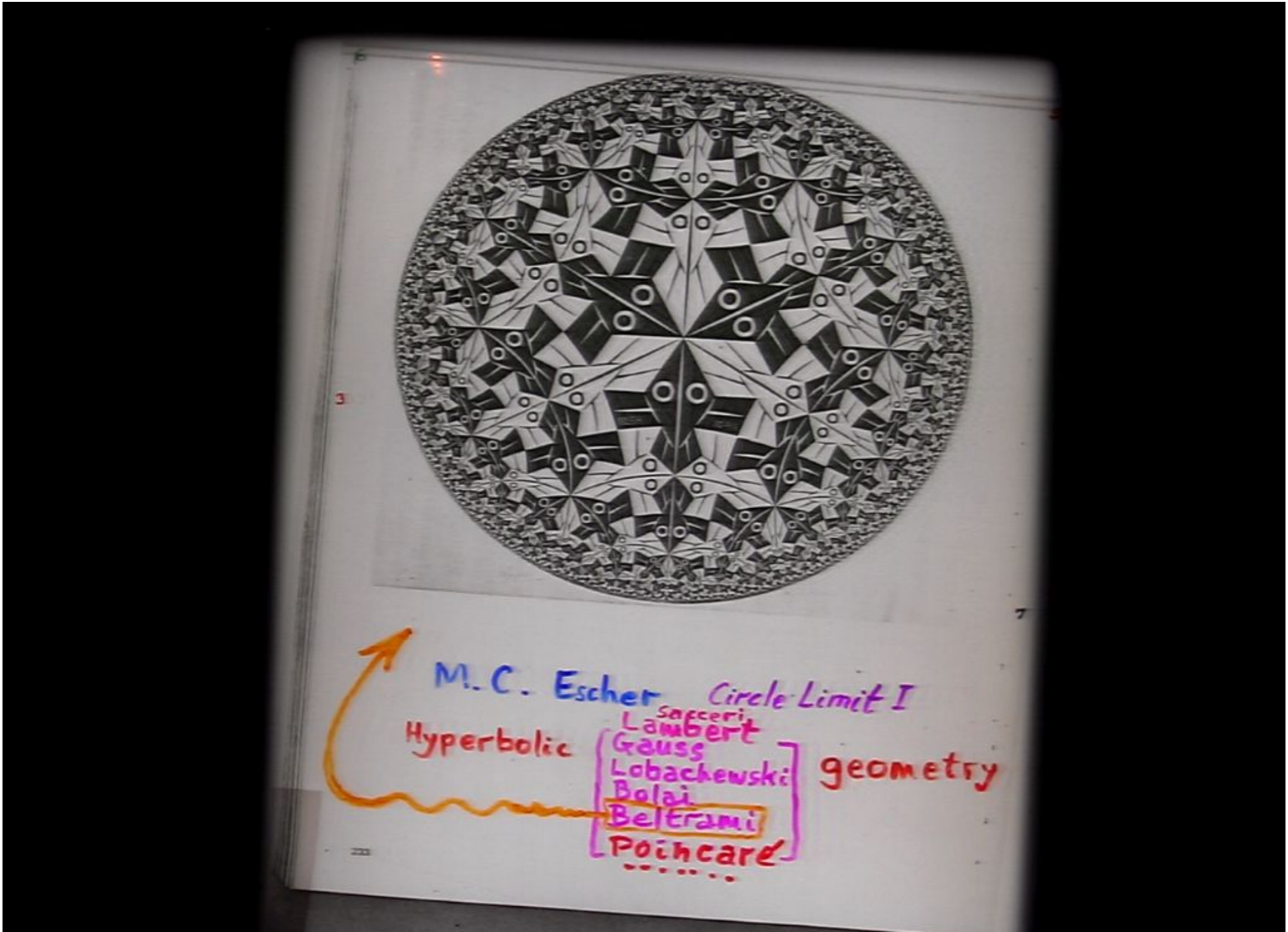
Poincaré
...
geometry


M. C. Escher
Circle Limit I
Hyperbolic
Saccheri
Lambert
Gauss
Lobachewski
Bolai
Beltrami
Poincaré
geometry



M. C. Escher *Circle Limit I*

Hyperbolic geometry

- Saccheri
- Lambert
- Gauss
- Lobachewski
- Bolai
- Beltrami
- Poincaré
- .....



M. C. Escher *Circle Limit I*

Hyperbolic geometry

- Saccheri
- Lambert
- Gauss
- Lobachewski
- Bolai
- **Beltrami**
- Poincaré
- .....



M. C. Escher Circle Limit I

Hyperbolic

Saccheri
Lambert
Gauss
Lobachewski
Bolai
Beltrami
Poincaré
.....

geometry



M. C. Escher Circle Limit I

Hyperbolic

- Saccheri
- Lambert
- Gauss
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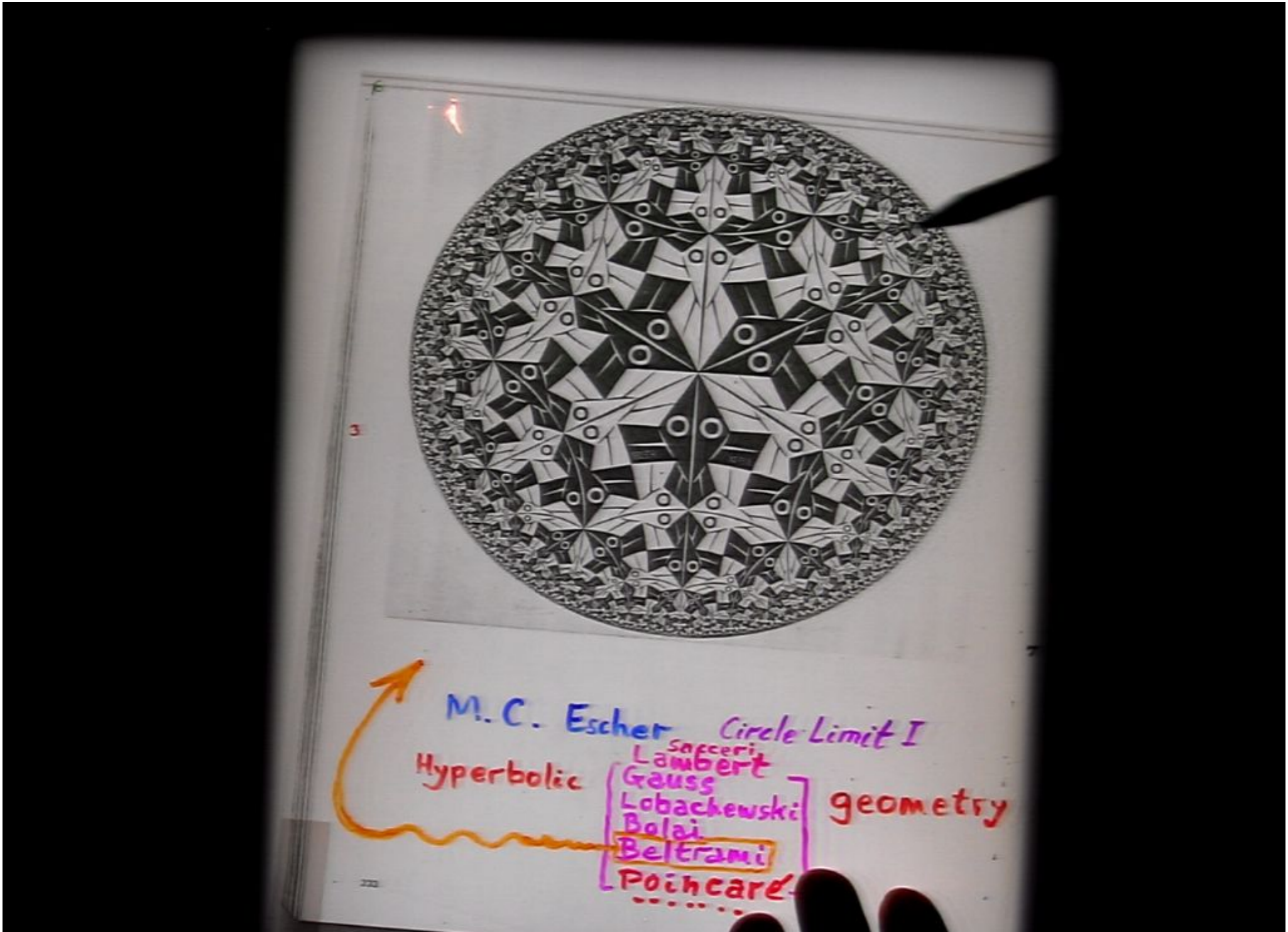
- Beltrami
- Poincaré
- .....

geometry


M. C. Escher
Circle Limit I
Hyperbolic
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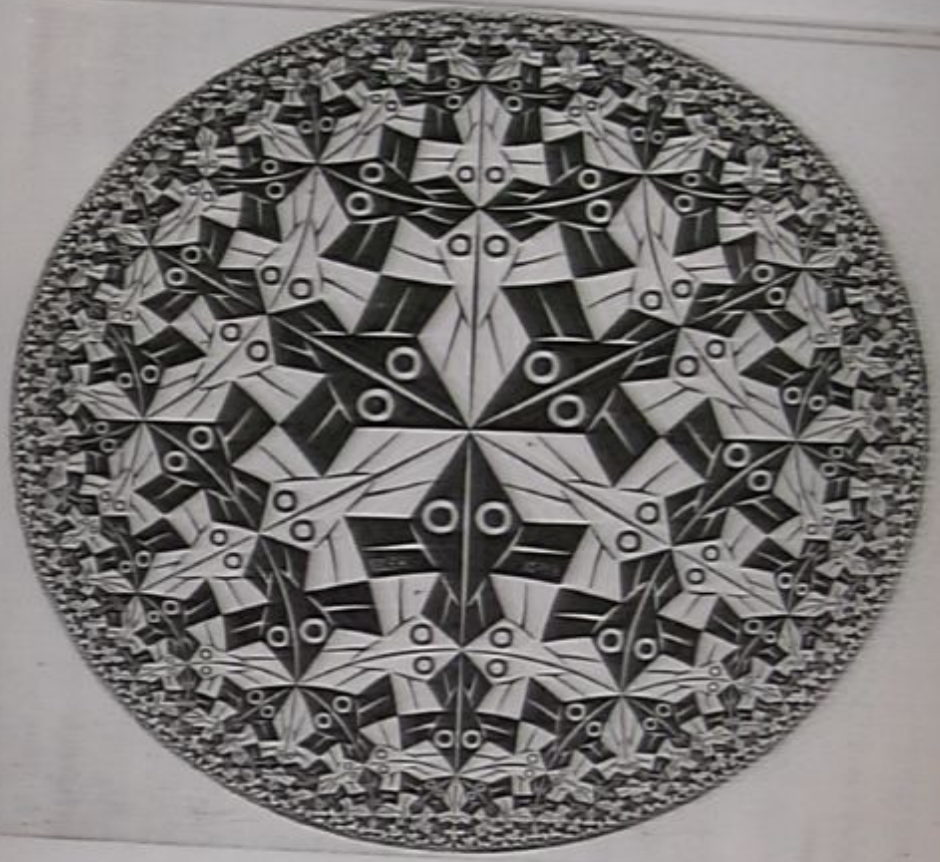
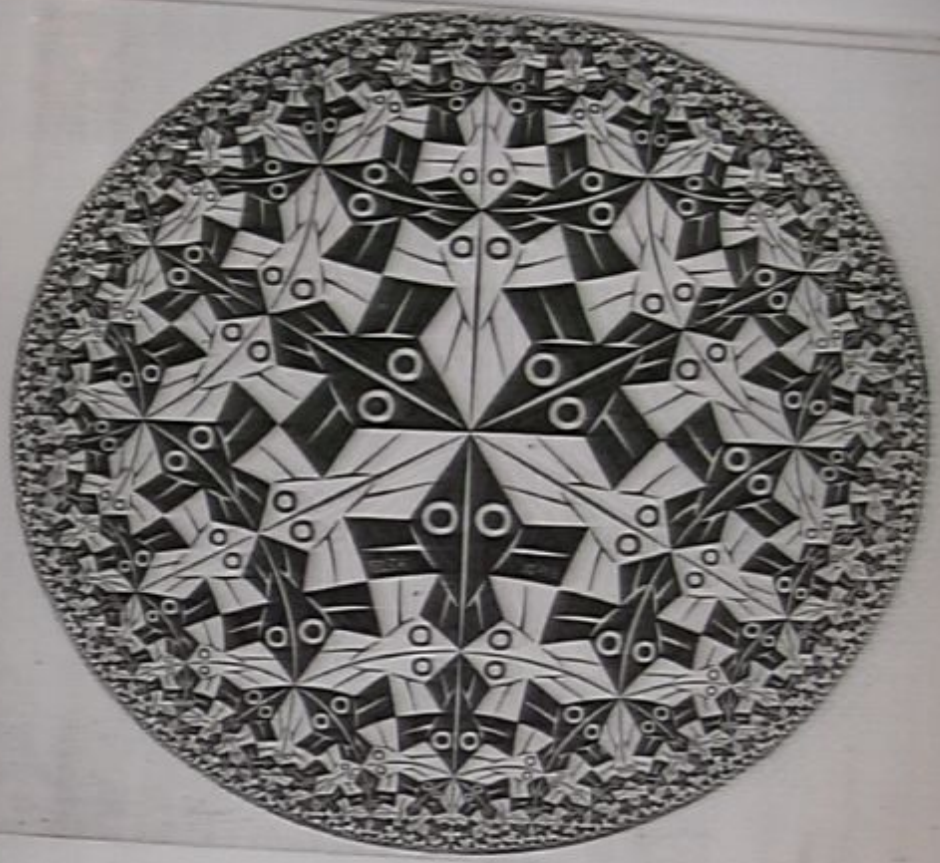
Poincaré
geometry



M. C. Escher *Circle Limit I*

Hyperbolic [Saccheri, Lambert, Gauss, Lobachewski, Bolai, Beltrami, Poincaré .....] geometry



M. C. Escher Circle Limit I

Hyperbolic [Saccheri, Lambert, Gauss, Lobachewski, Bolai, Beltrami, Poincaré .....] geometry



M. C. Escher Circle Limit I

Hyperbolic [Saccheri, Lambert, Gauss, Lobachewski, Bolai, Beltrami, Poincaré .....] geometry



M. C. Escher Circle Limit I

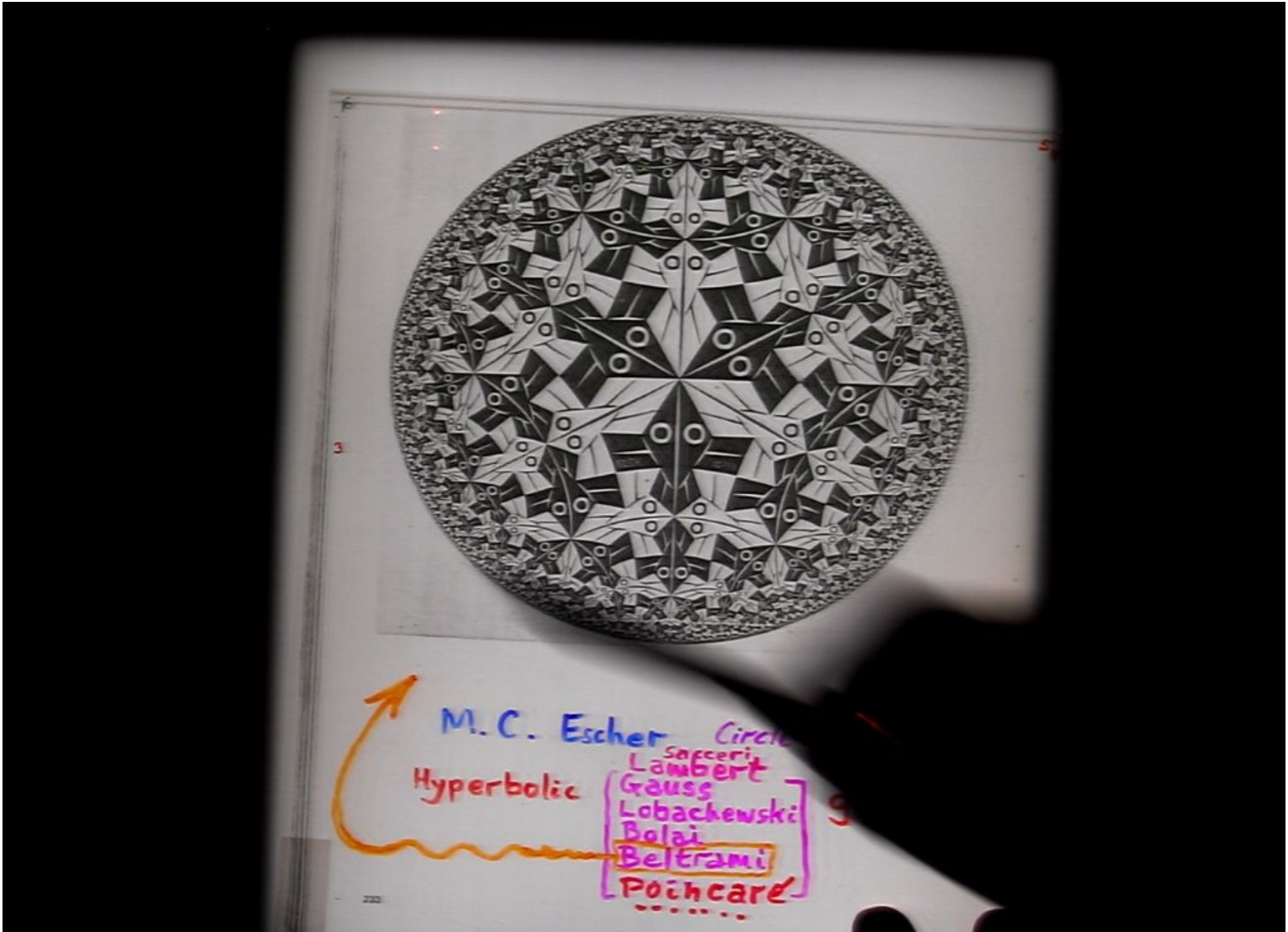
Hyperbolic geometry

- Saccheri
- Lambert
- Gauss
- Lobachewski
- Bolai
- Beltrami
- Poincaré
- .....



M. C. Escher *Circle Limit I*

Hyperbolic [Saccheri, Lambert, Gauss, Lobachewski, Bolai, Beltrami, Poincaré .....] geometry


M. C. Escher
Hyperbolic
Saccheri
Lambert
Gauss
Lobachewski
Bolai
Beltrami
Poincaré



M. C. Escher *Circle Limit I*

Hyperbolic geometry

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- Lambert
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- .....



M. C. Escher *Circle Limit I*

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M. C. Escher *Circle Limit I*

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M. C. Escher *Circle Limit I*

Hyperbolic geometry

Saccheri
Lambert
Gauss
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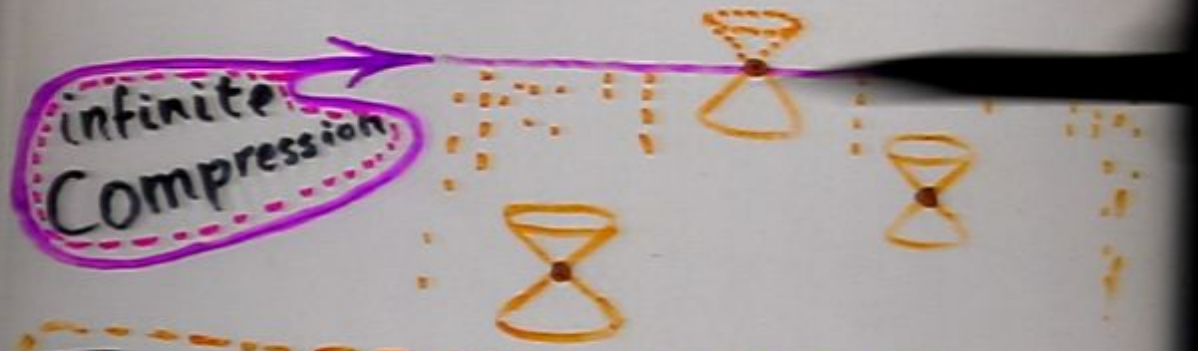
.....





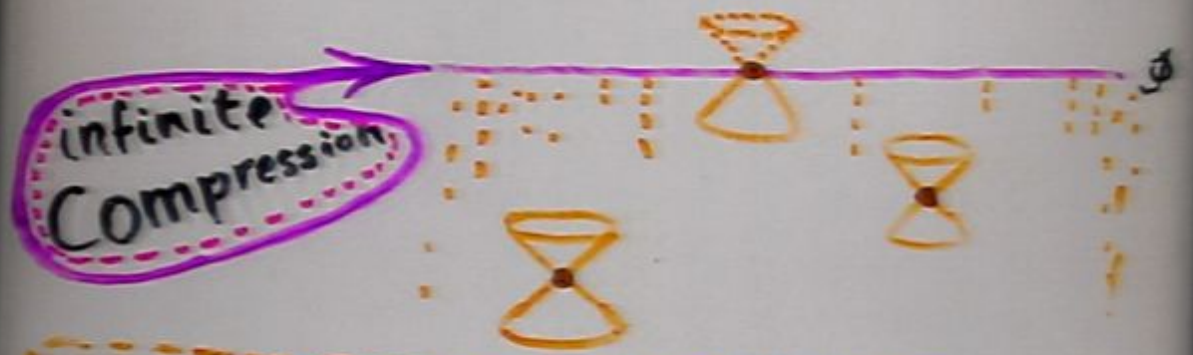


The extemely remote future

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 $M_\odot$, ~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

trons?
ration?



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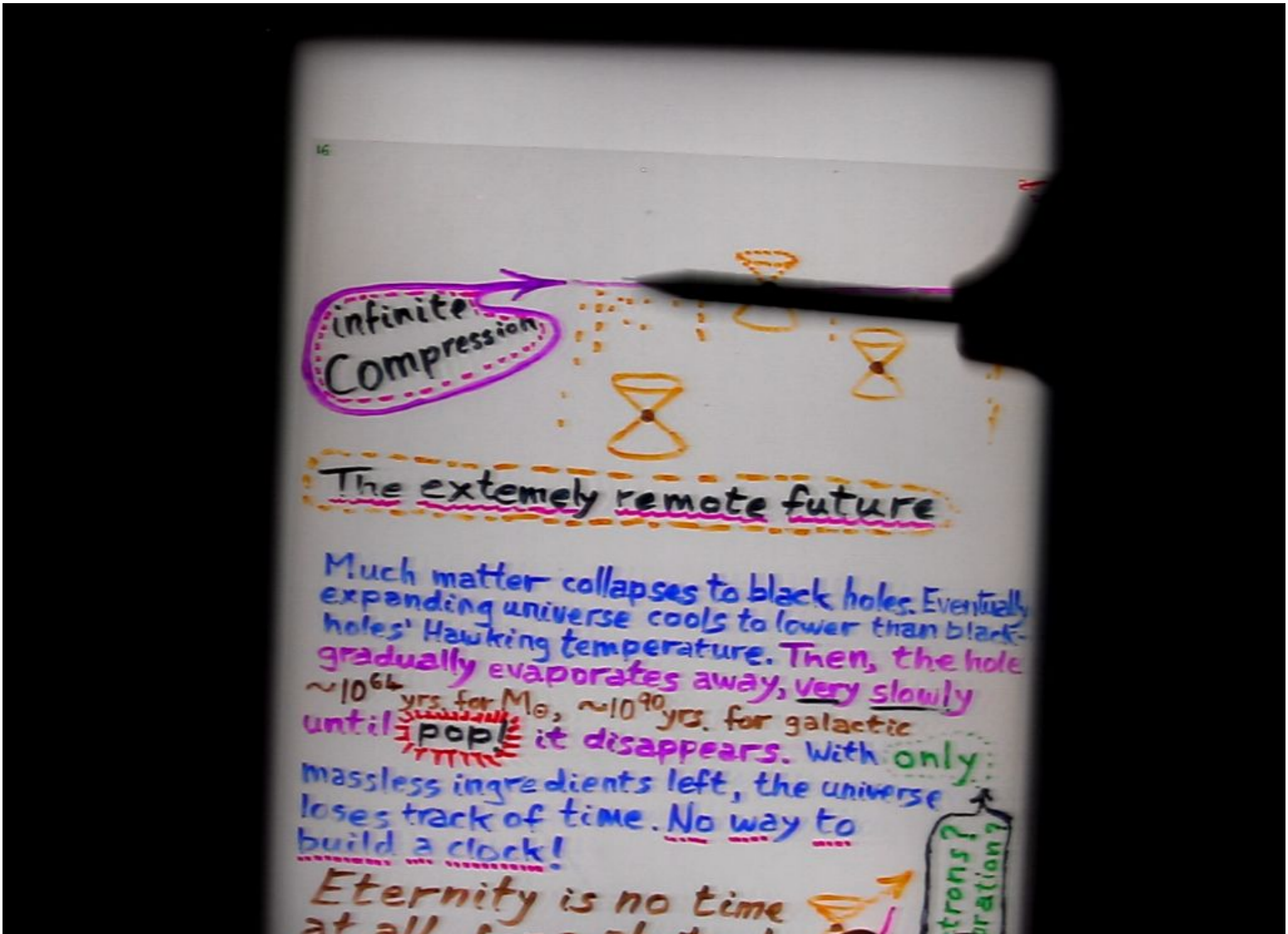
Eternity is no time

trons?
ration?


infinite Compression
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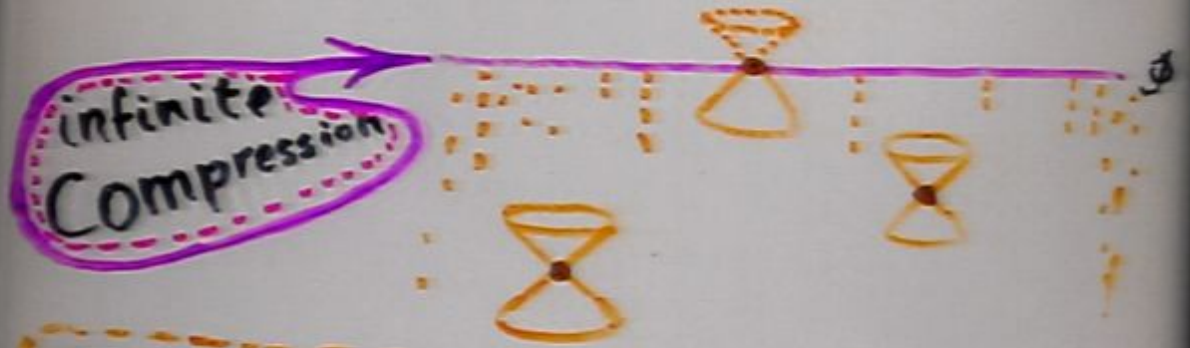

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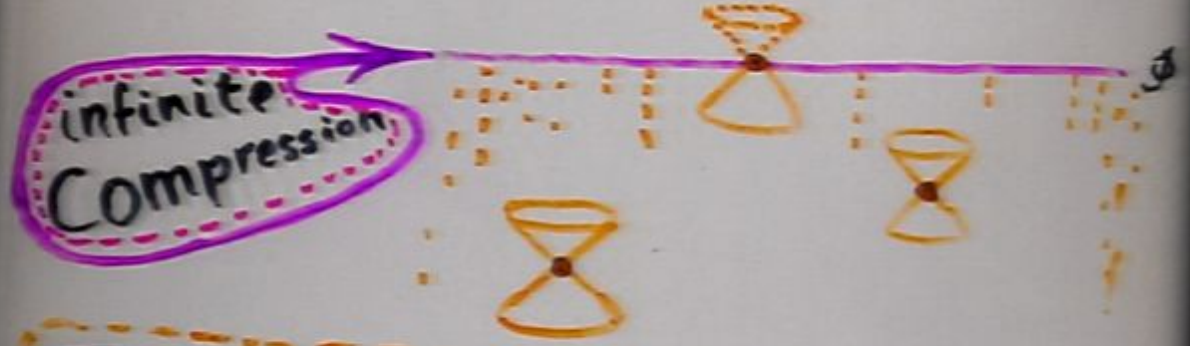
Eternity is no time





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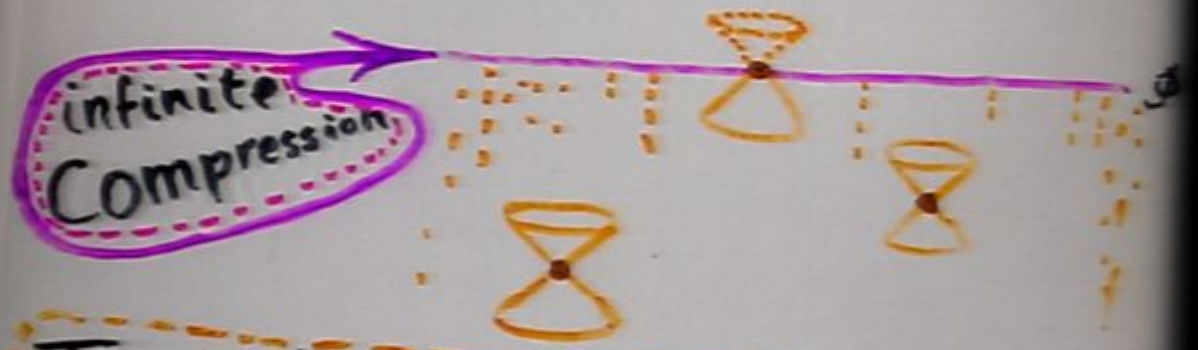
Eternity is no time at all





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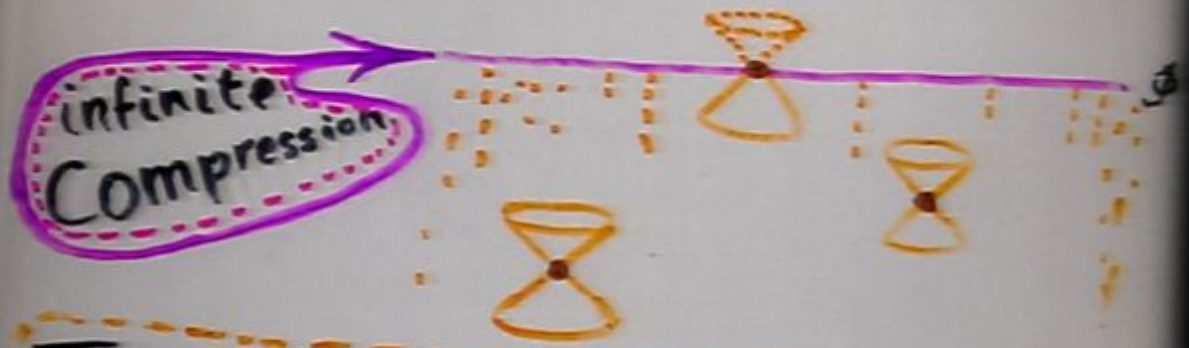
Eternity is no time at all, for a photon!





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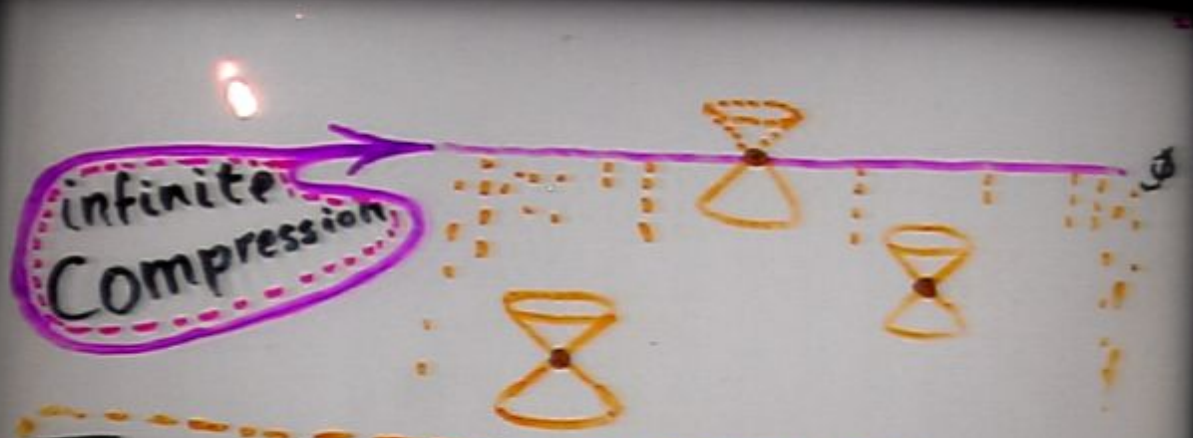

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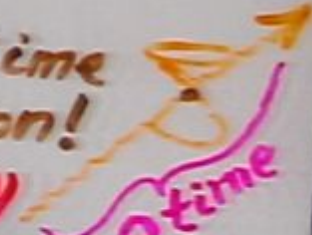
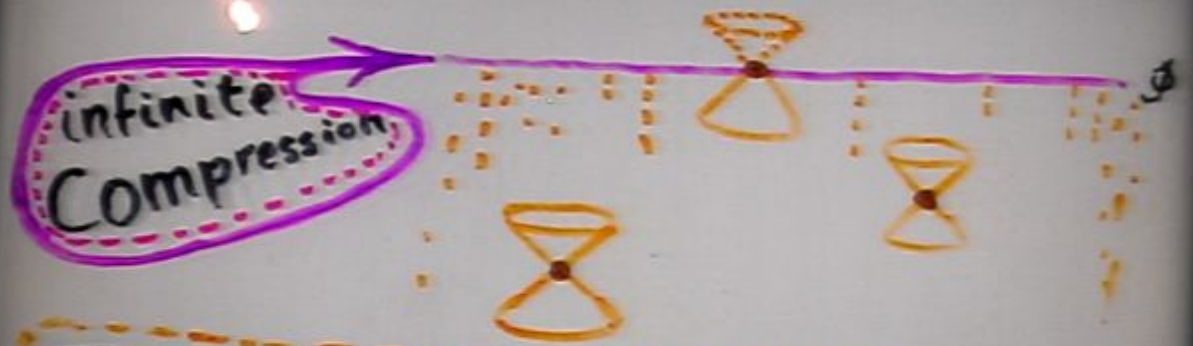
Conformal geometry

Conformal [illegible] ($\mathcal{I}$) [illegible] acelike

if $\Lambda > 0$ [illegible]







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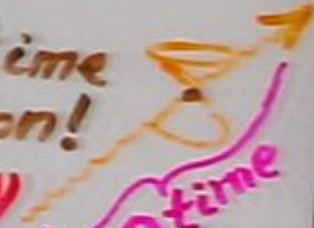
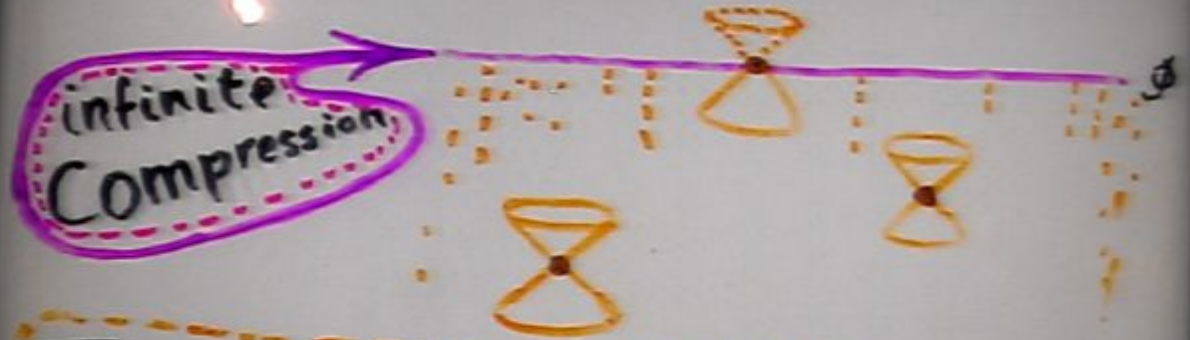


Conformal geometry

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





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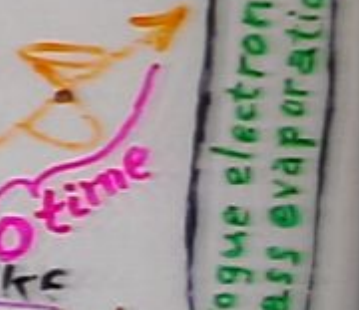

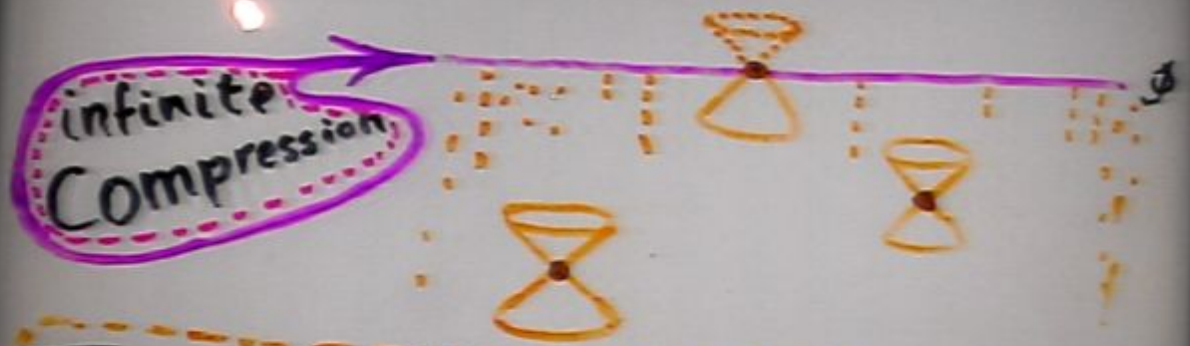

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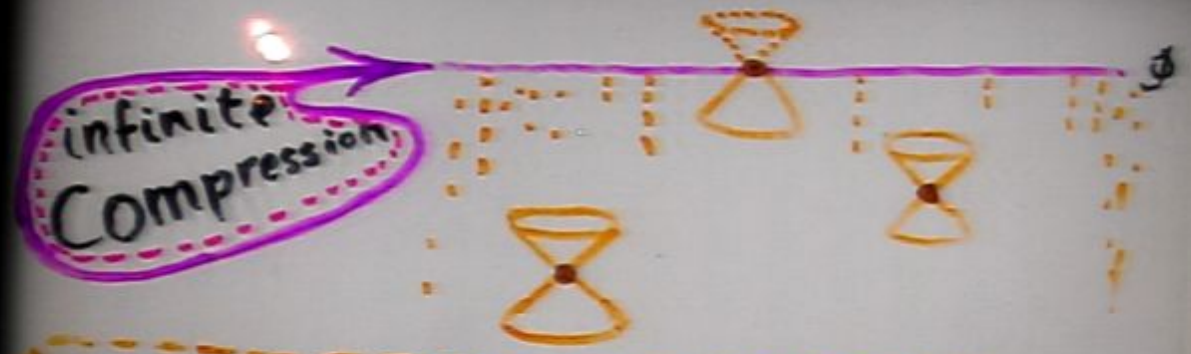

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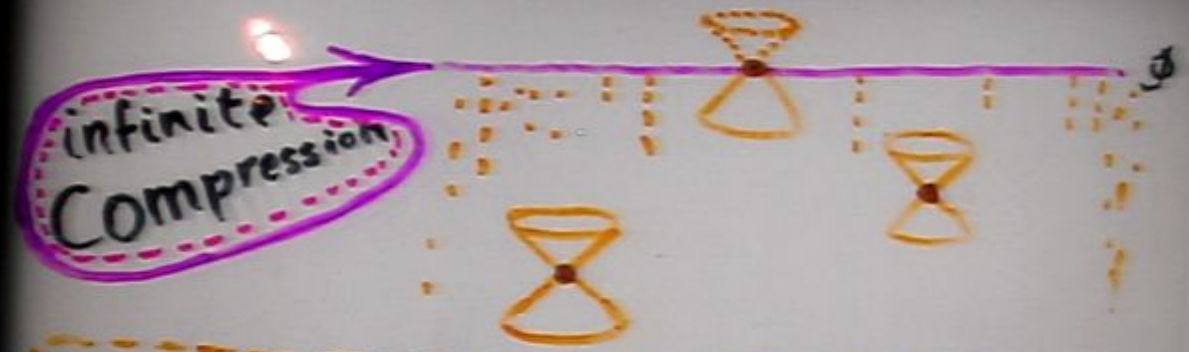

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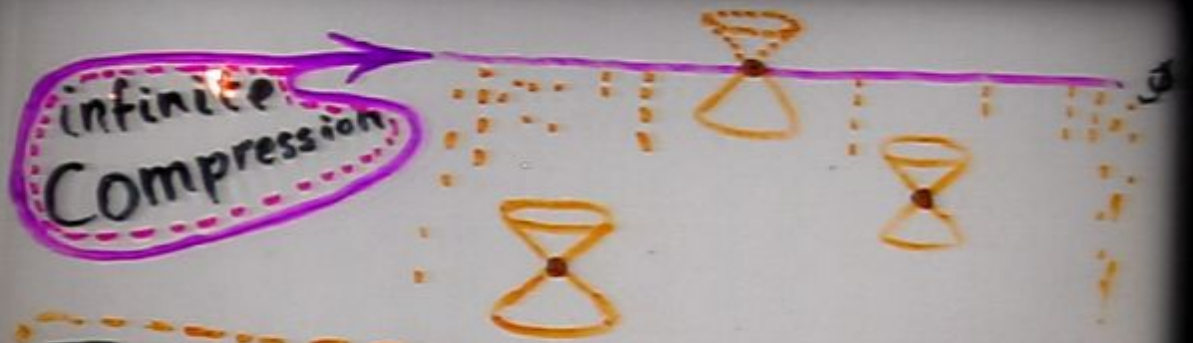
rogue electrons? mass evaporation?



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rogue electrons? mass evaporation?

(Infinite) Compression





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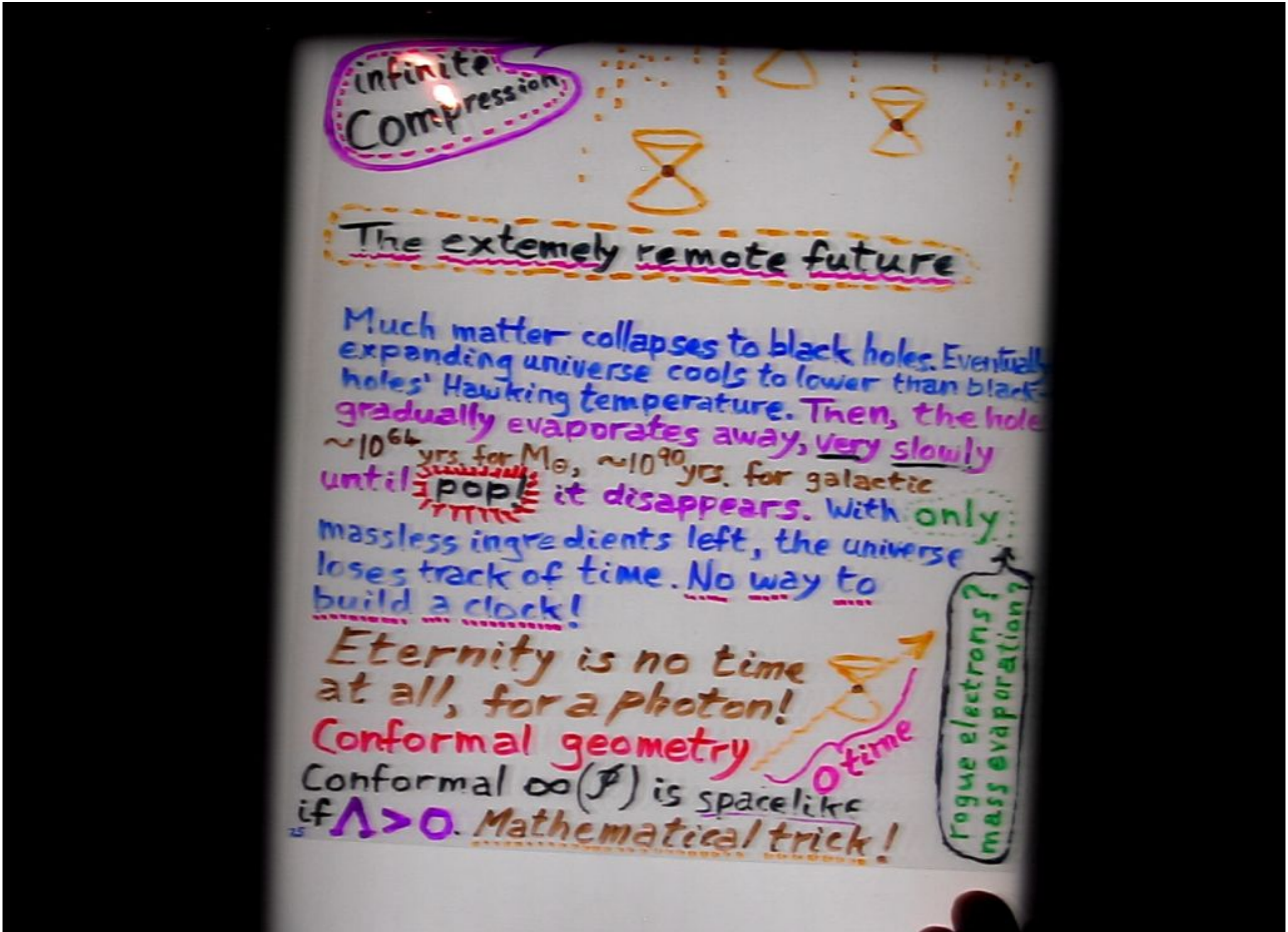
infinite Compression
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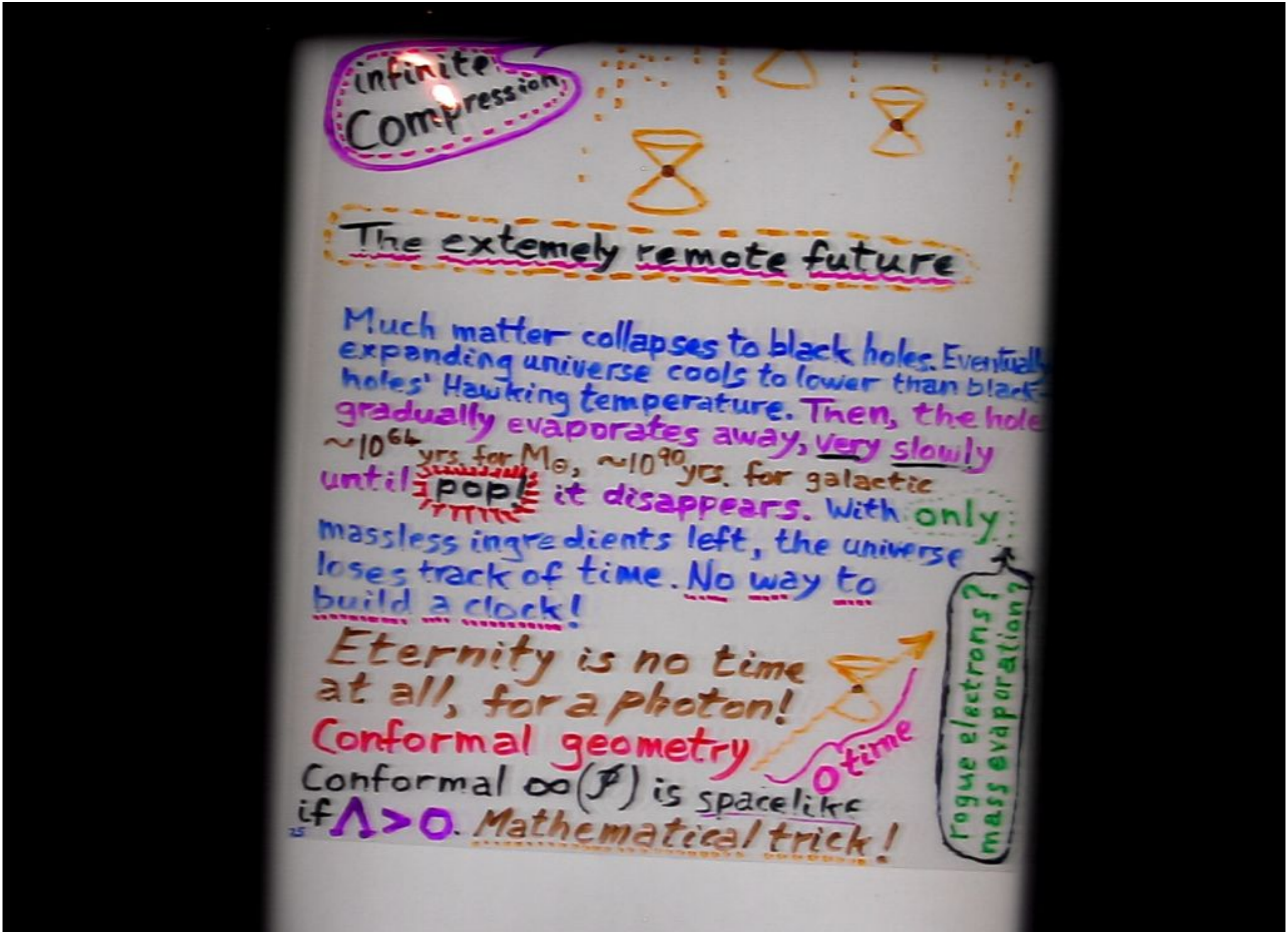
Conformal geometry
Conformal ∞(ℐ) is spacelike if Λ>0. Mathematical trick!
0 time
rogue electrons? mass evaporation?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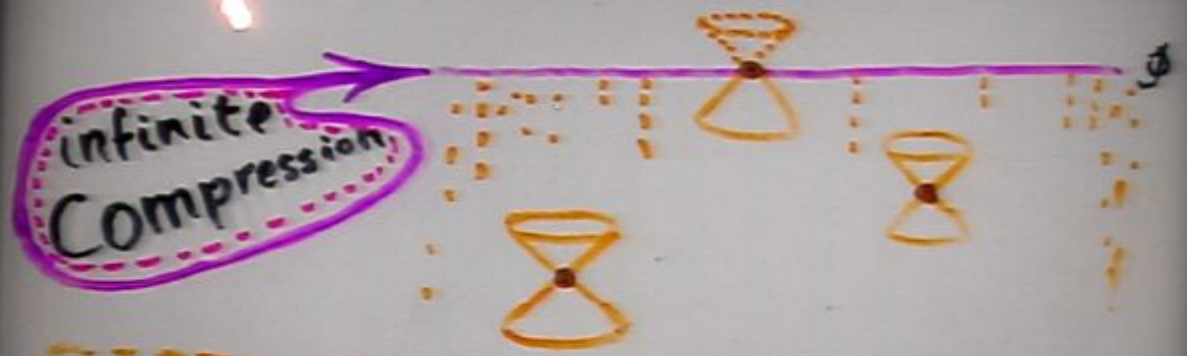

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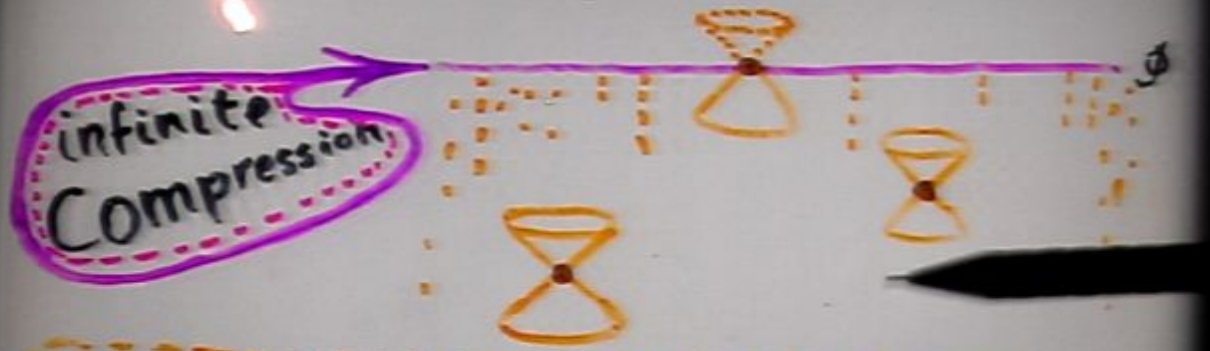
Conformal geometry



Conformal $\infty(\mathcal{I})$ is spacelike if $\Lambda > 0$

rogue electrons?
mass evaporation?



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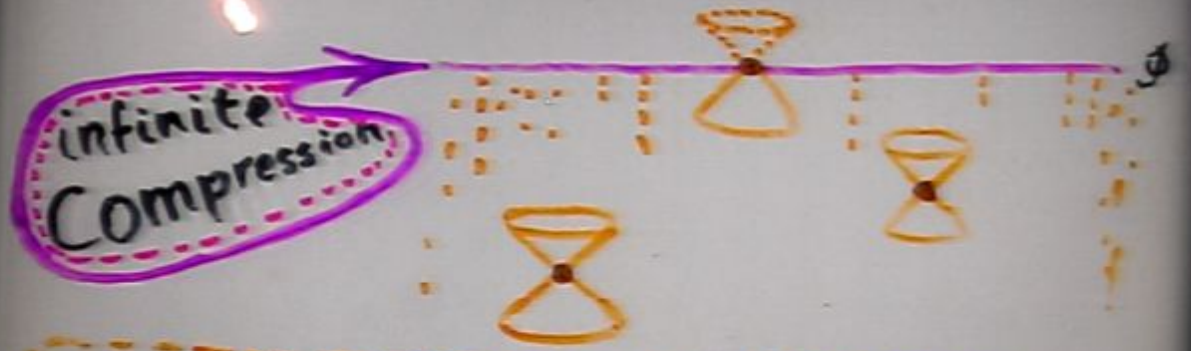

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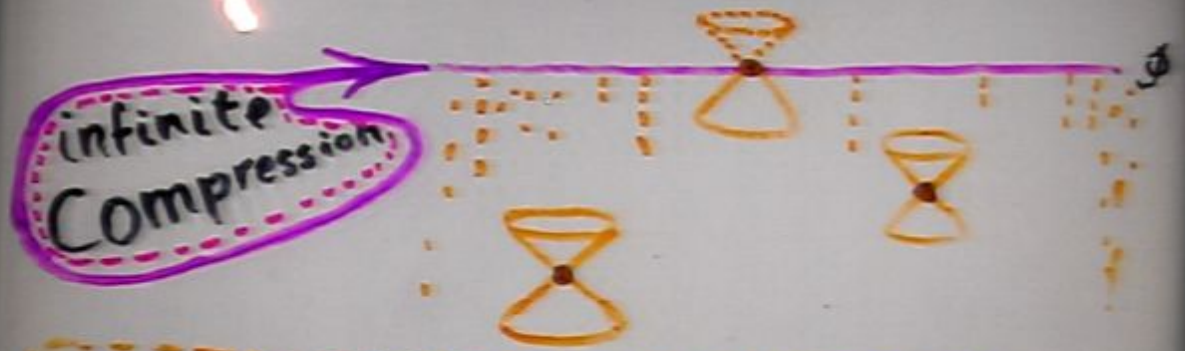

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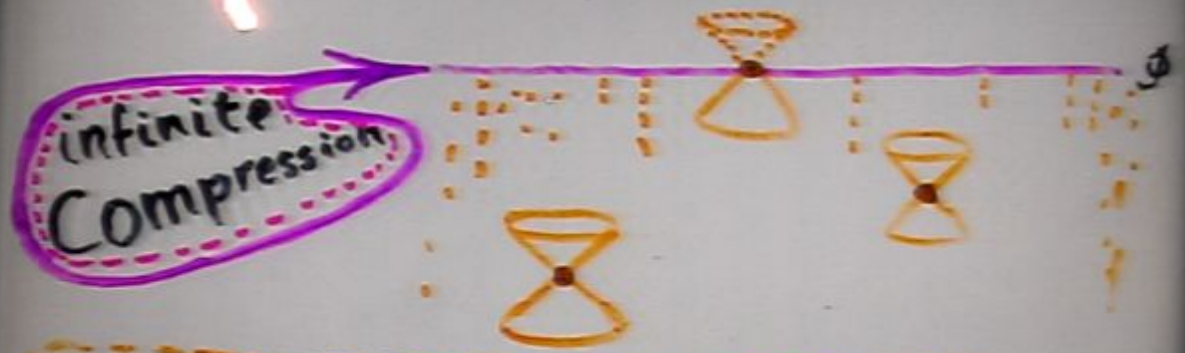

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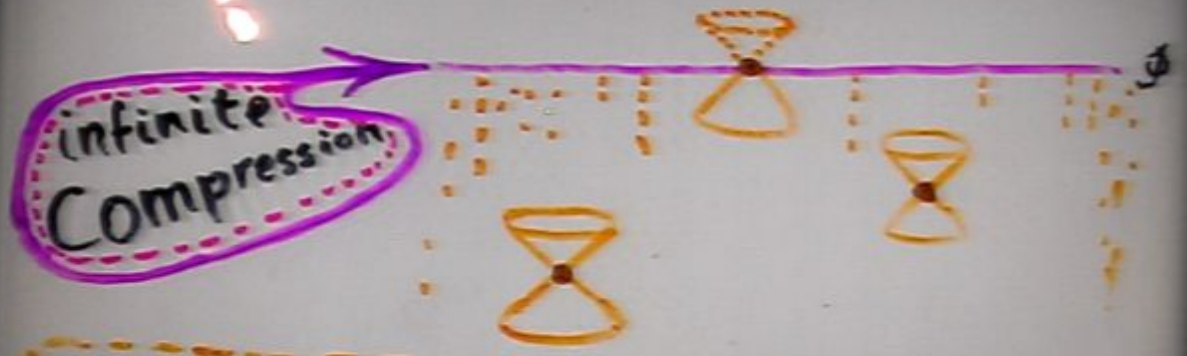

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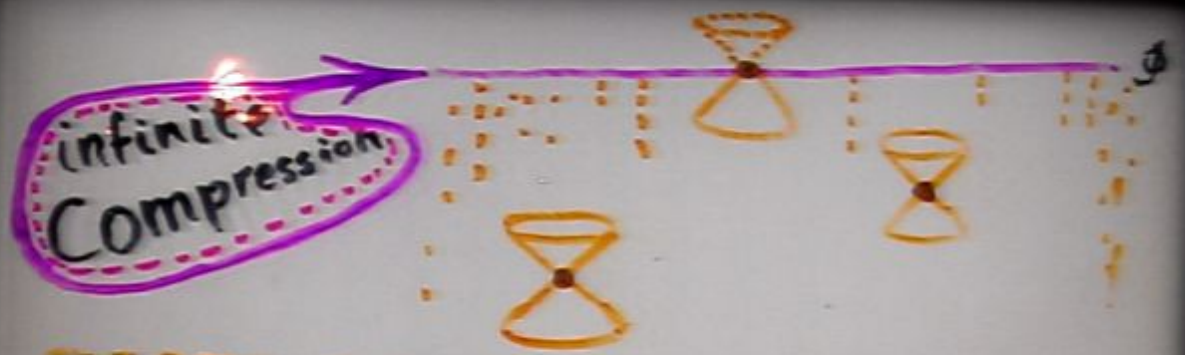

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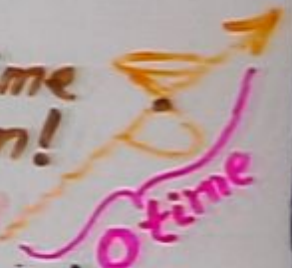

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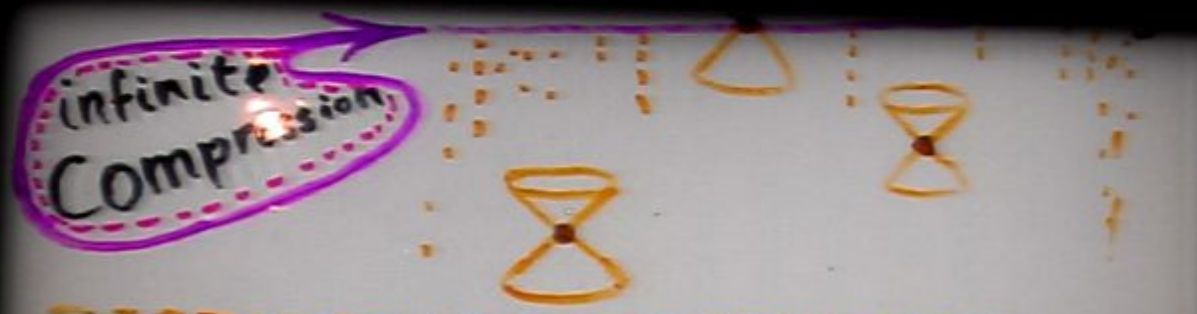

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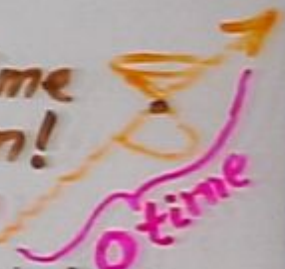

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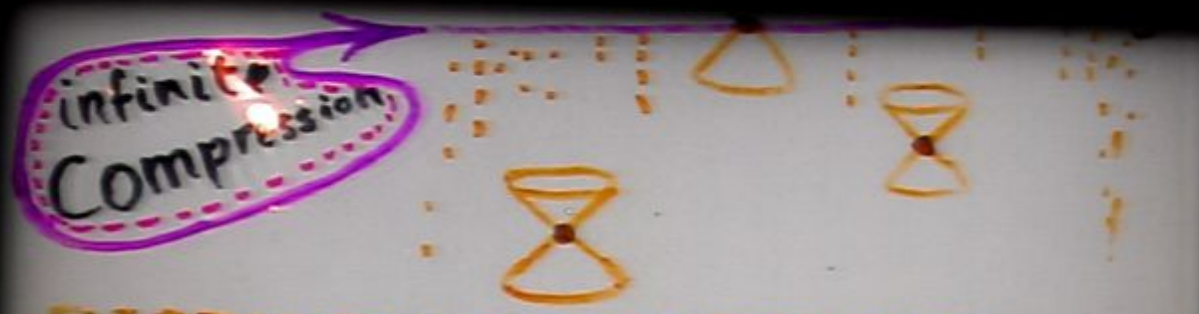

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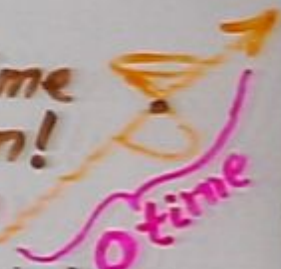

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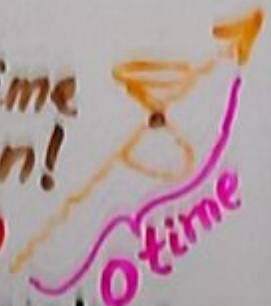

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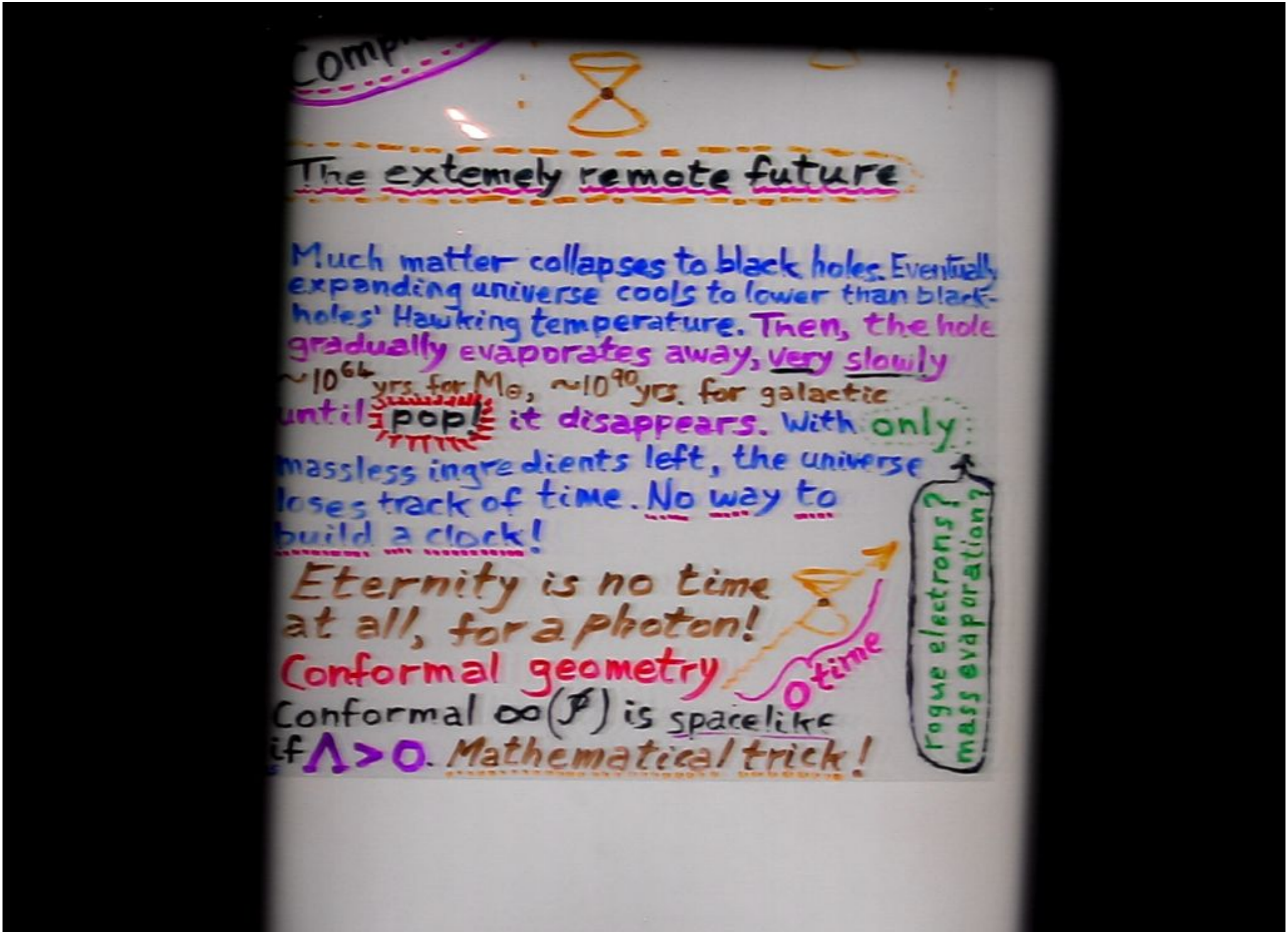
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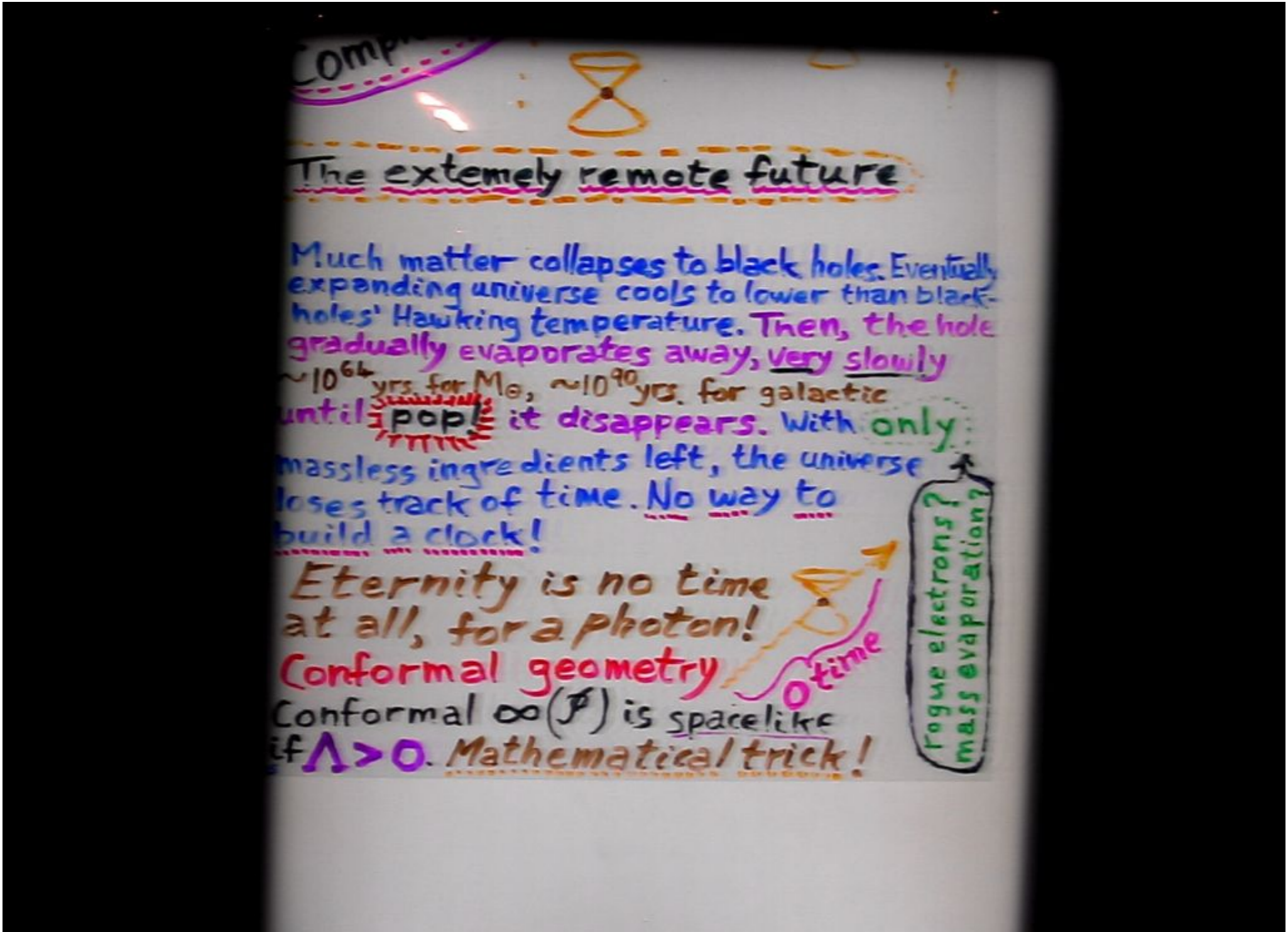
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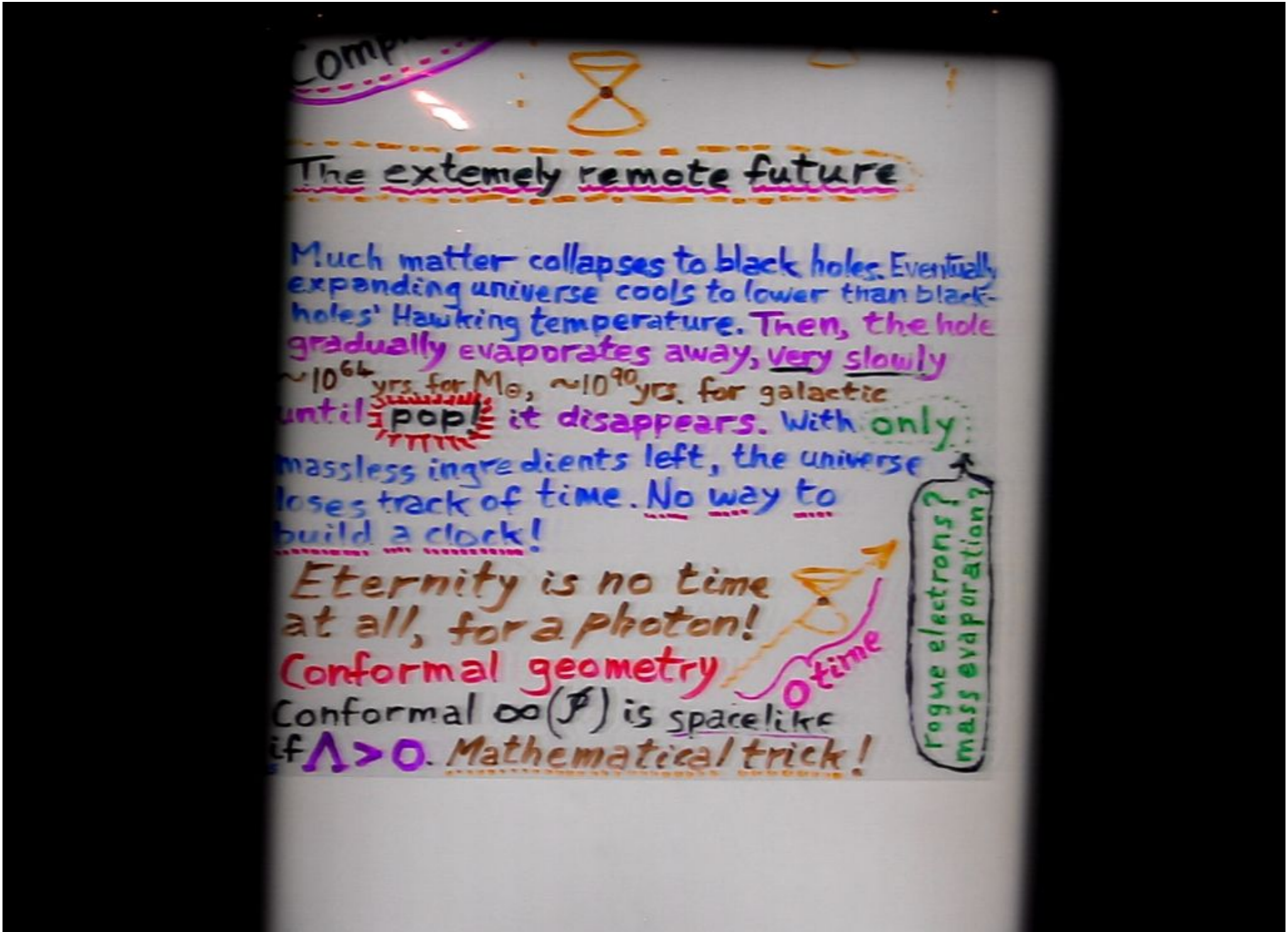
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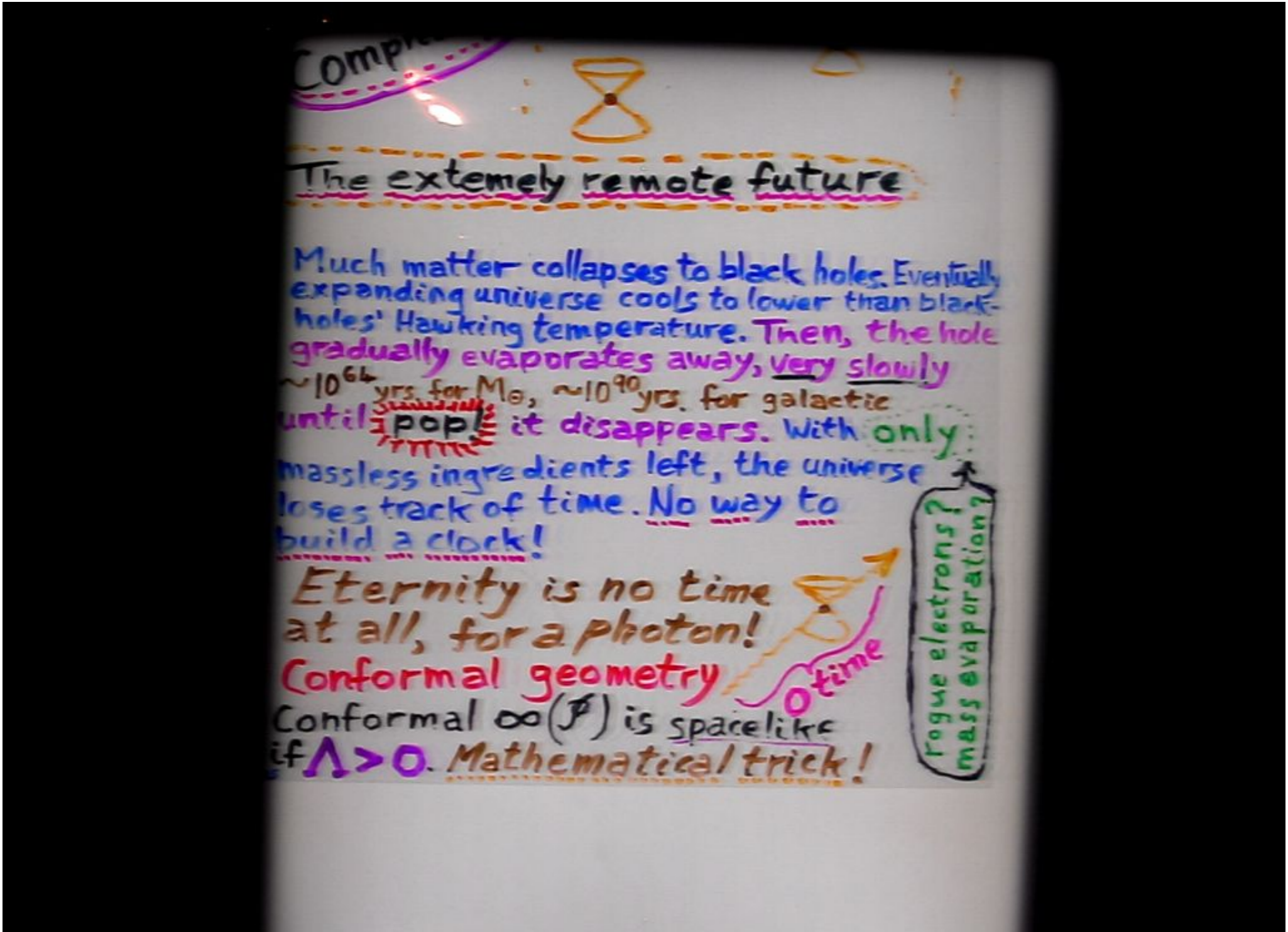
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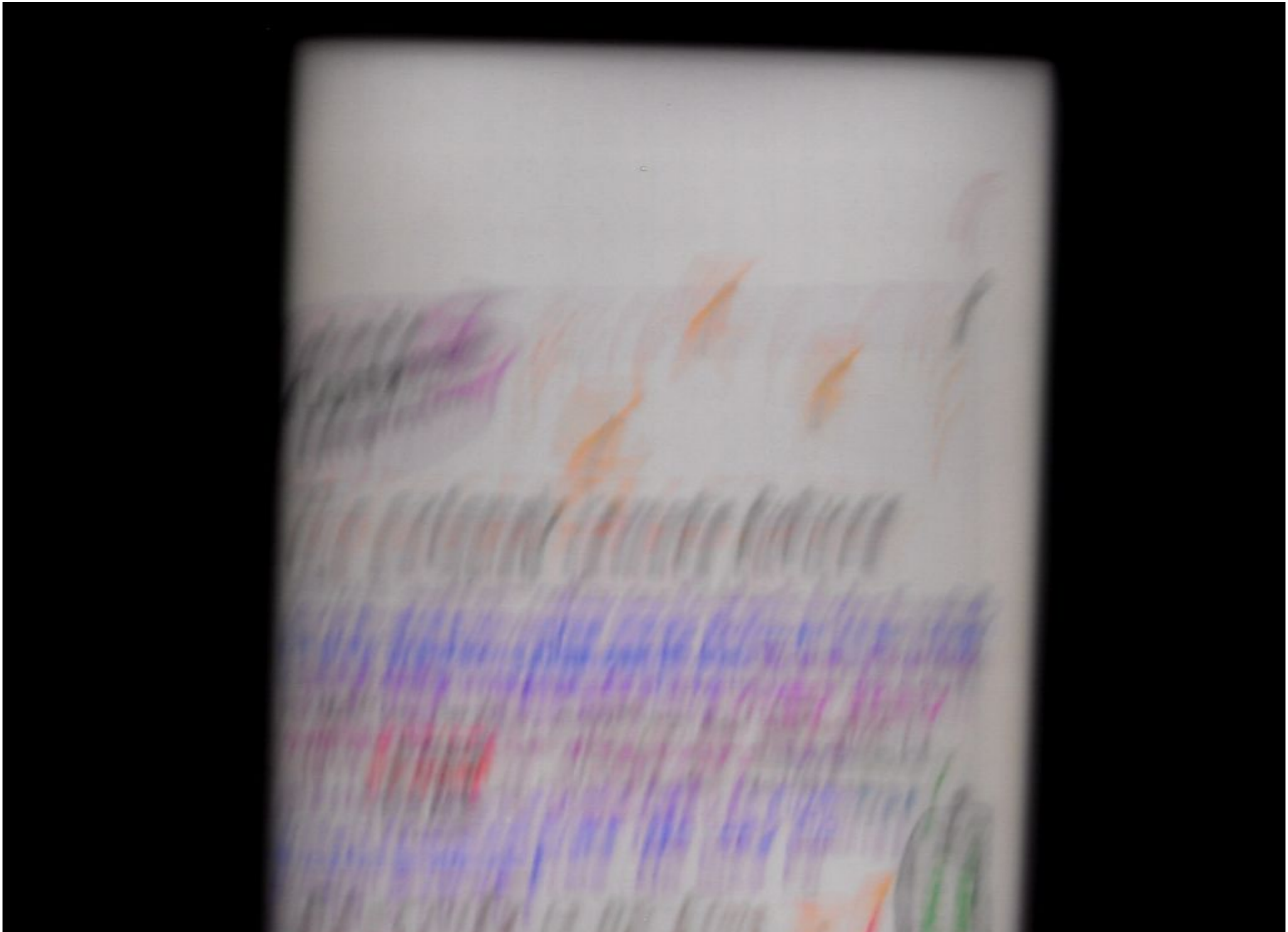



Weyl Curvature Hypothesis

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 (ie. as light-cone structure) to BEFORE



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

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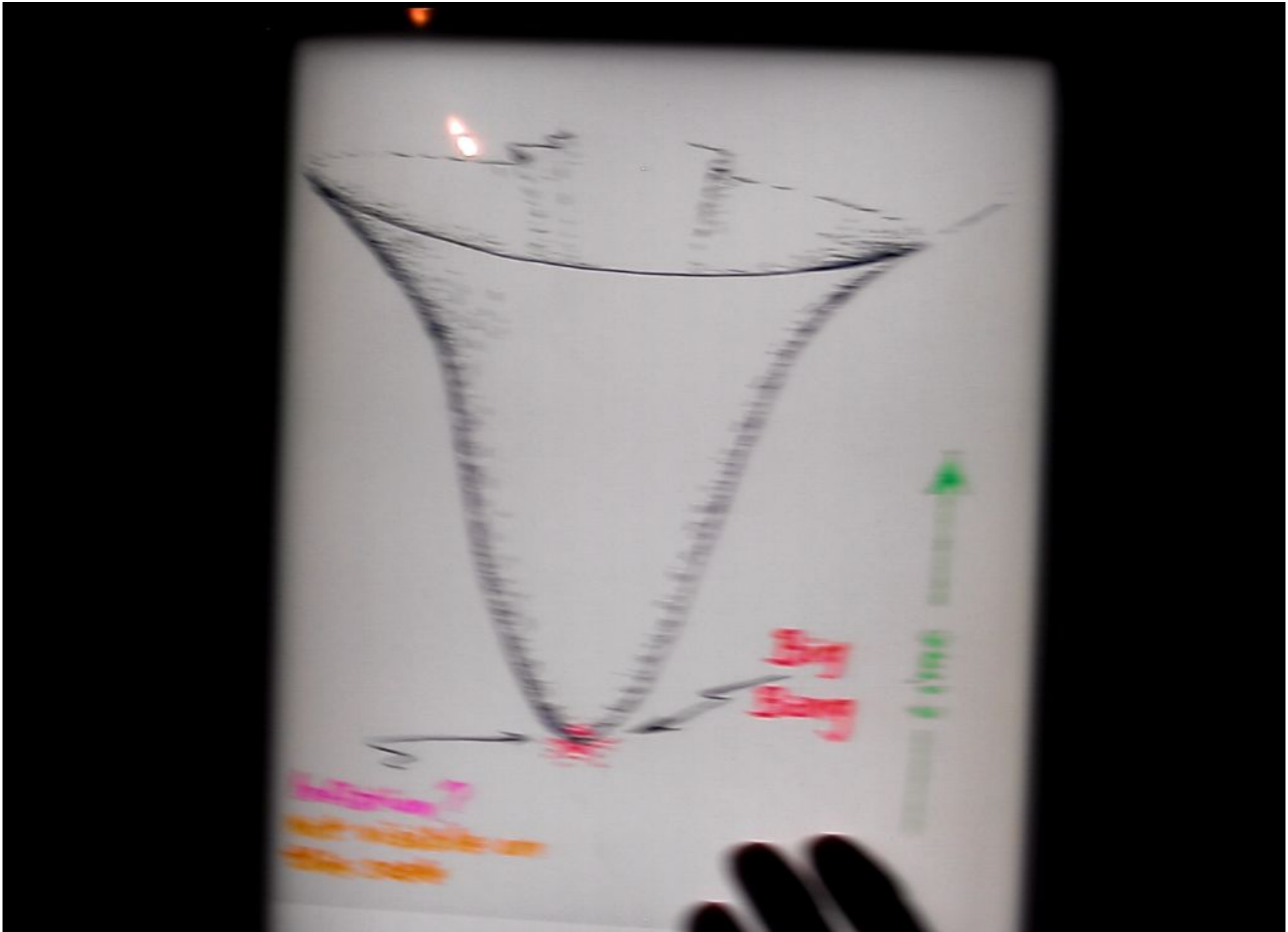

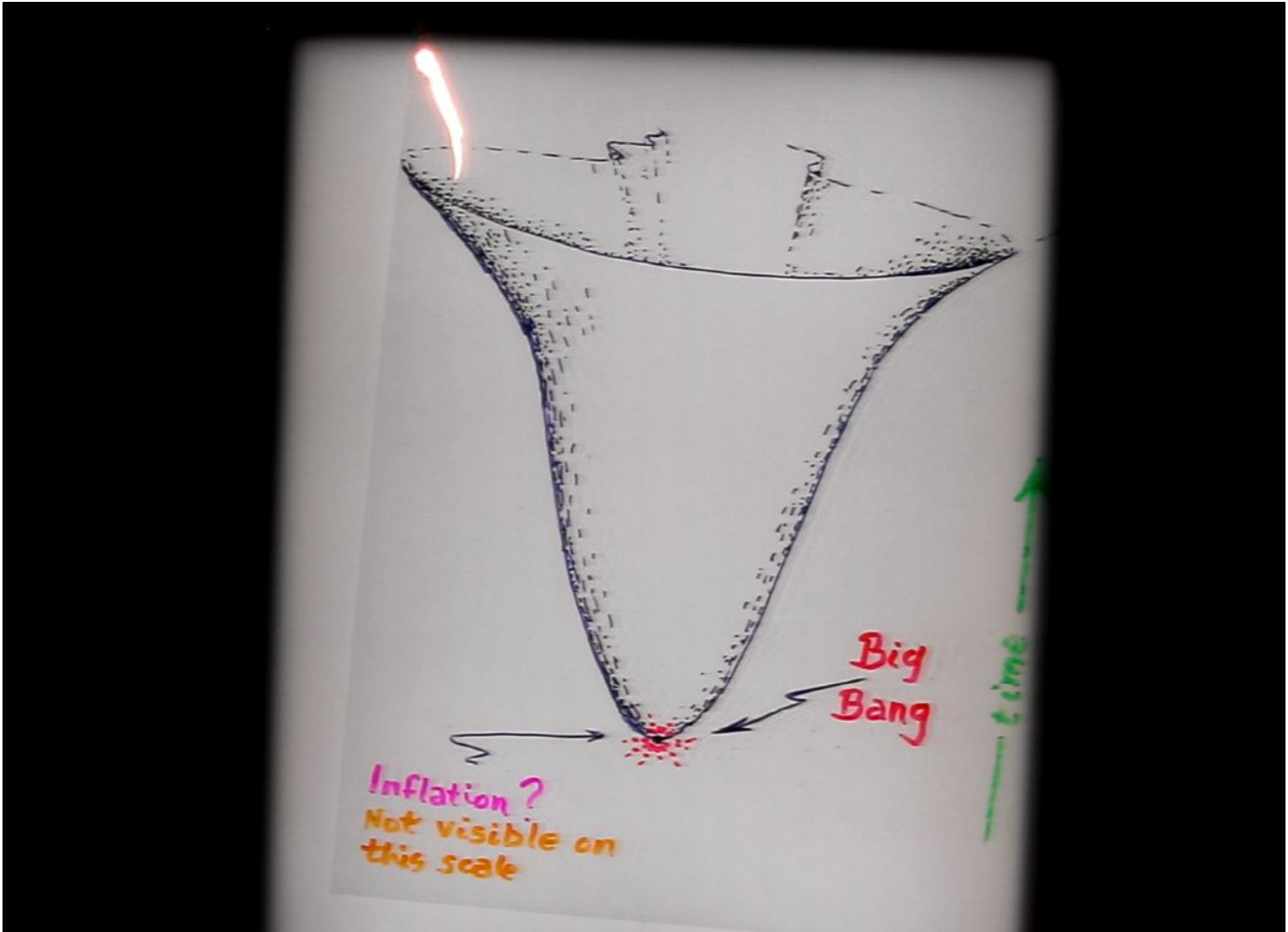
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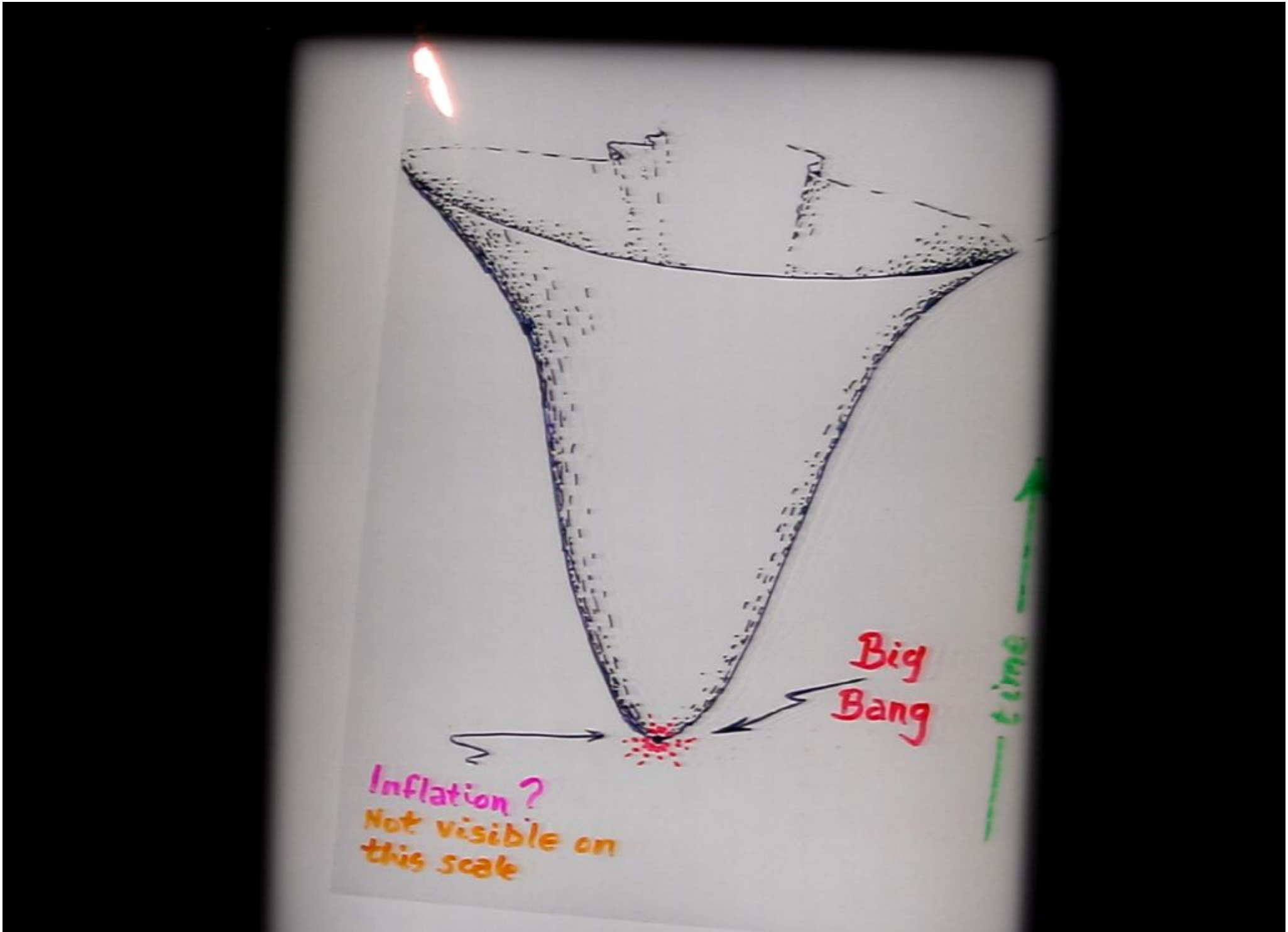
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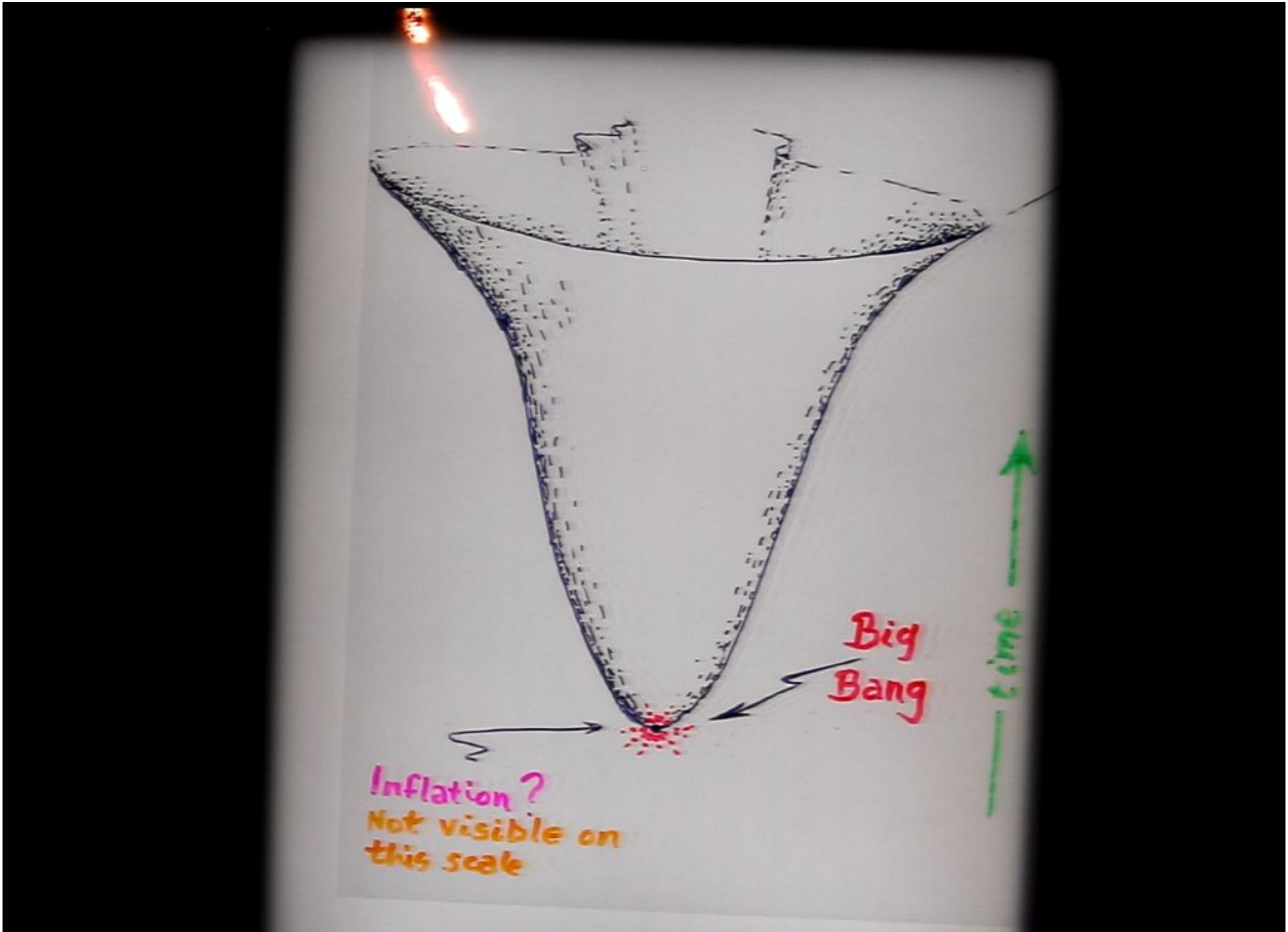
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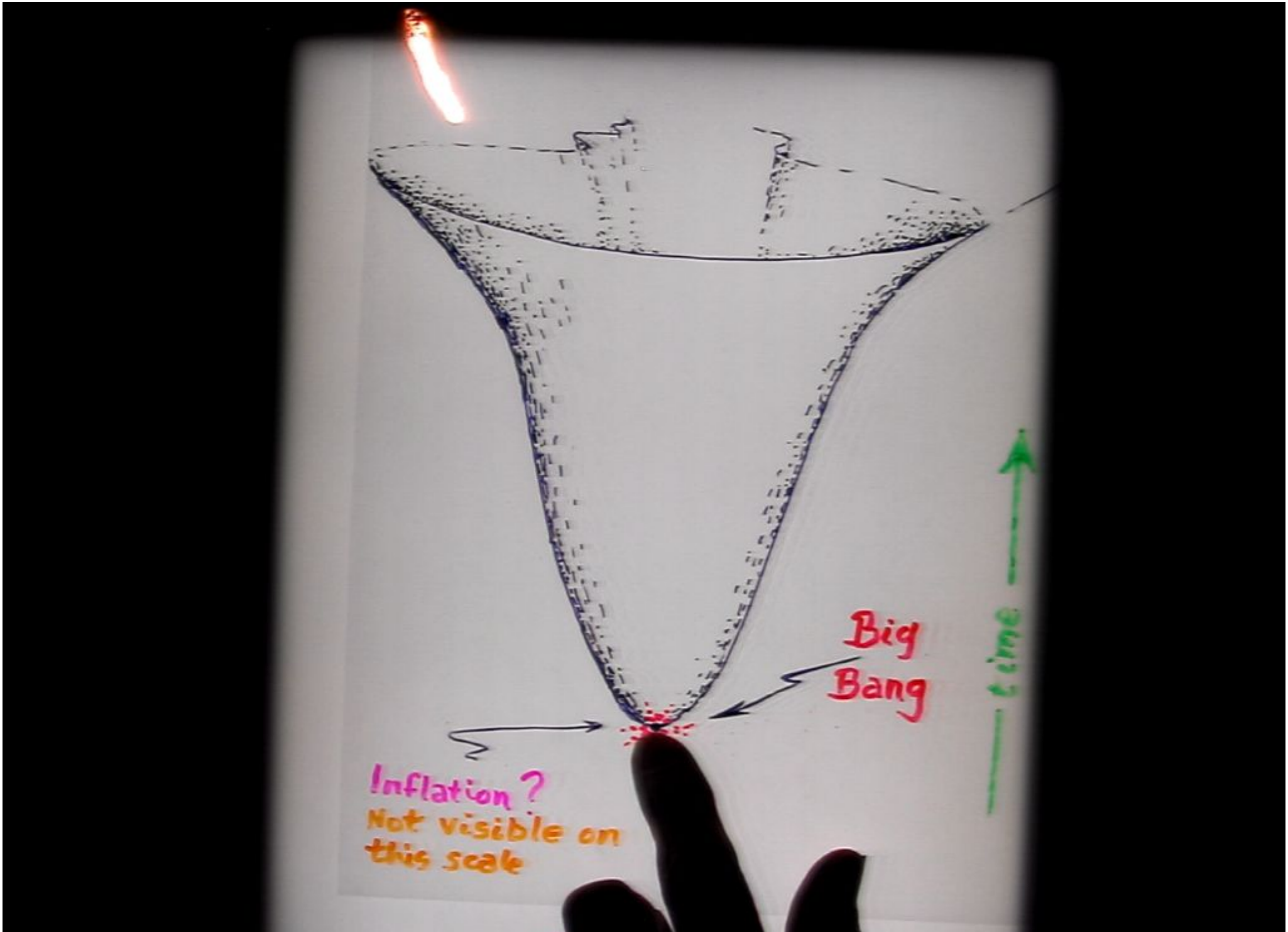
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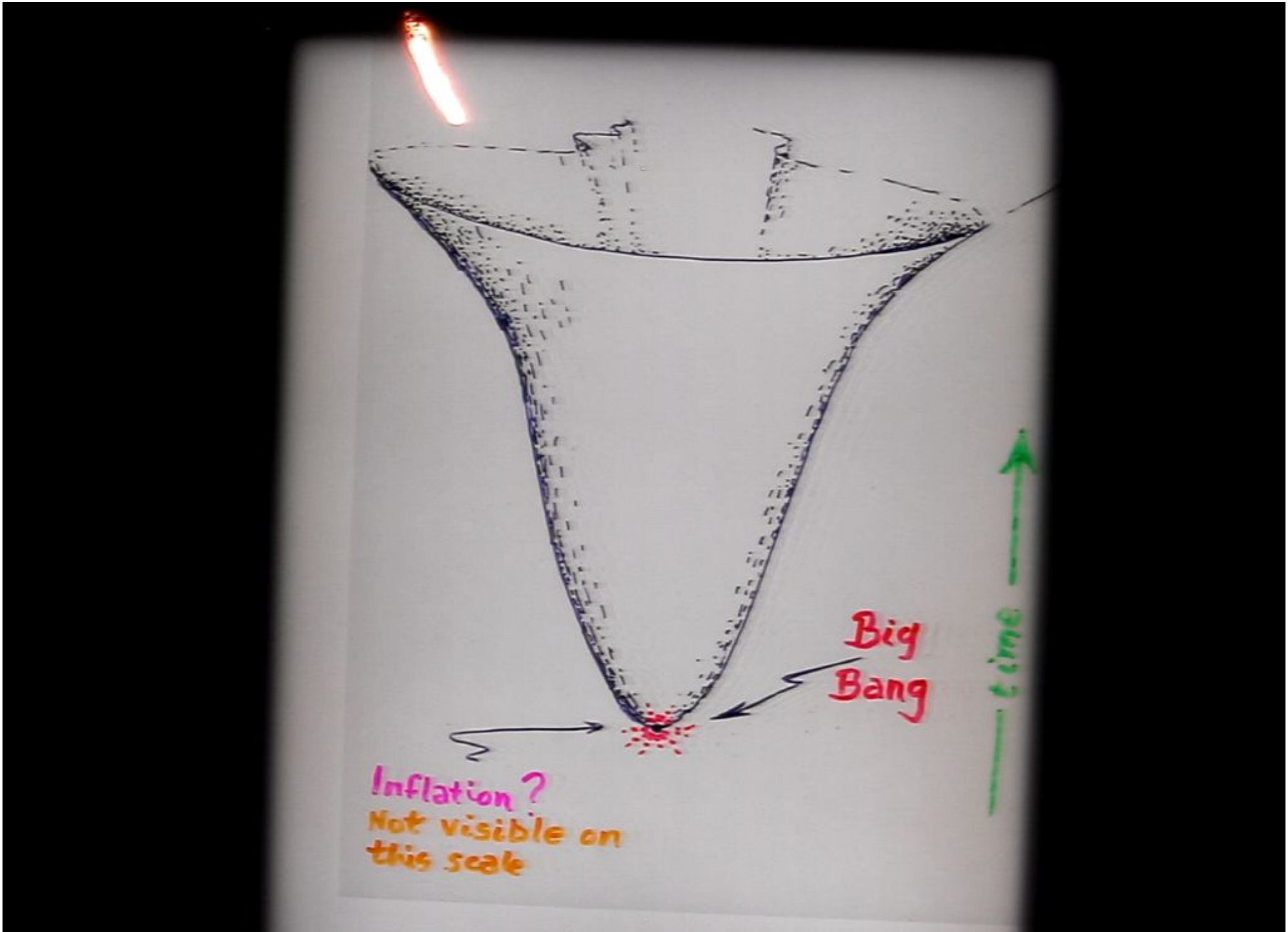
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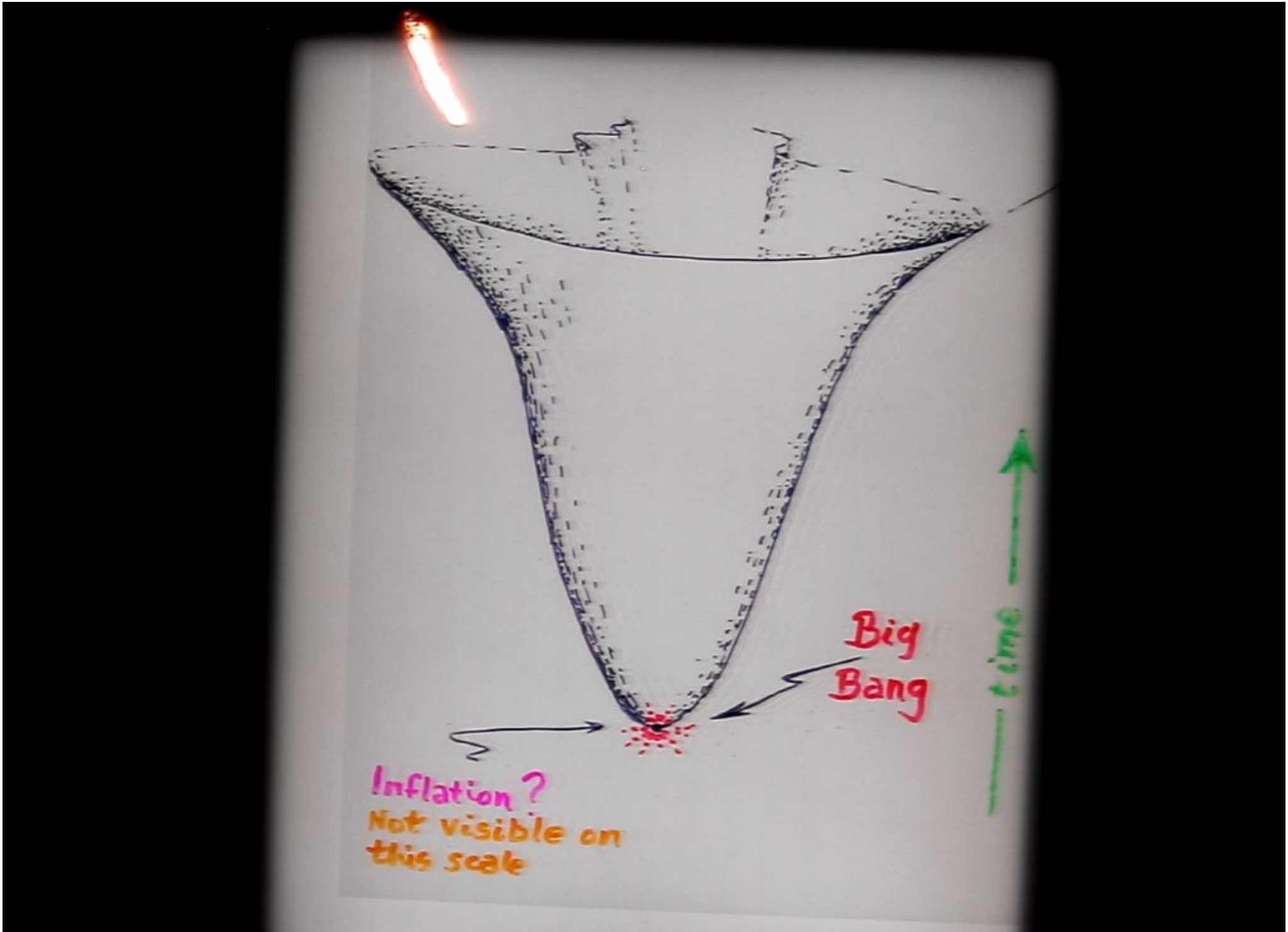
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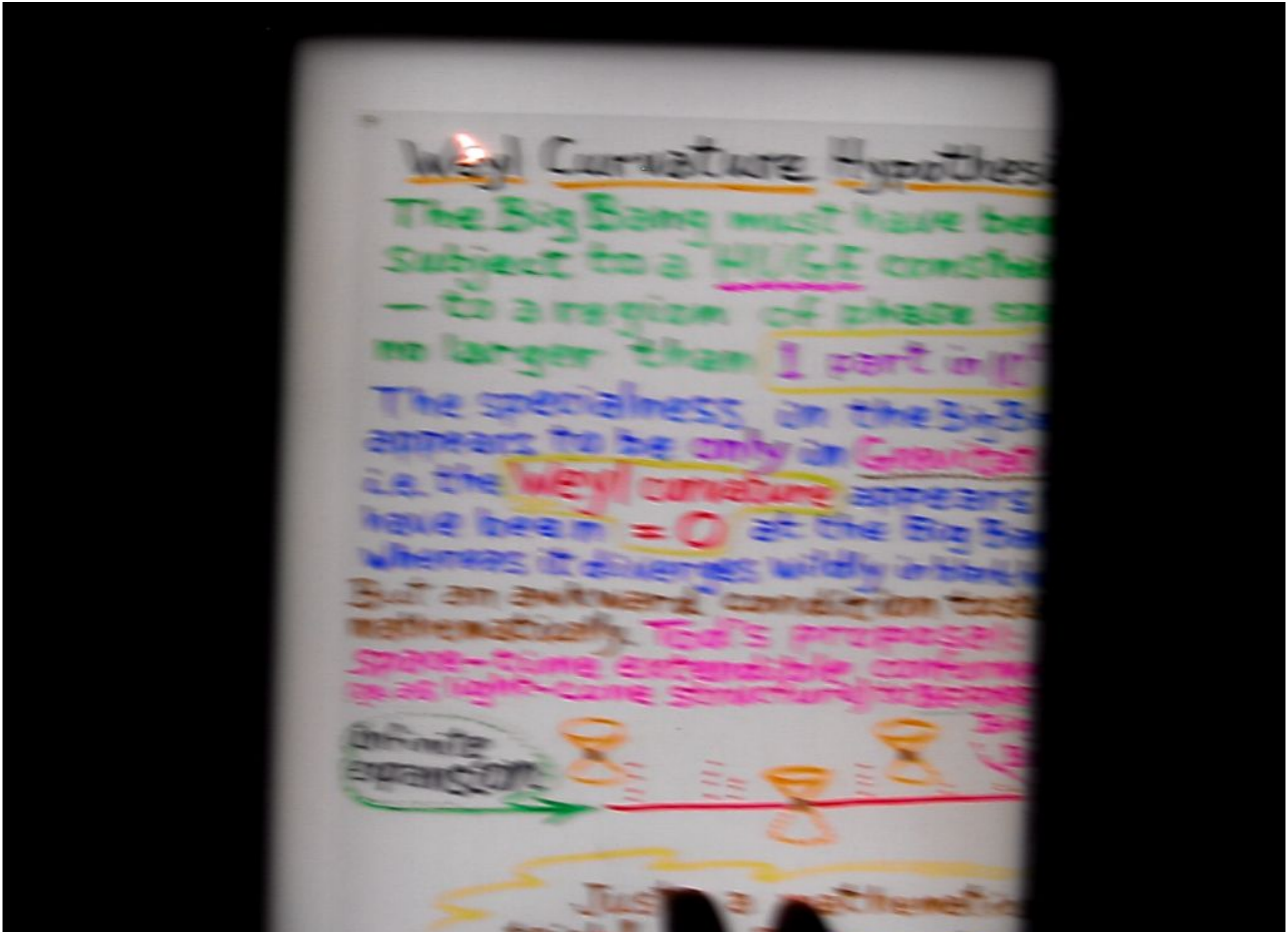
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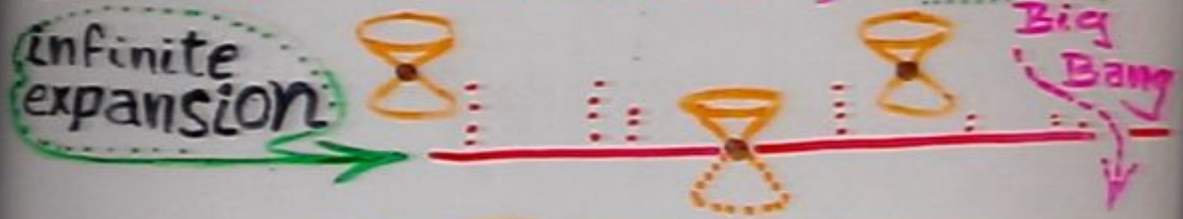

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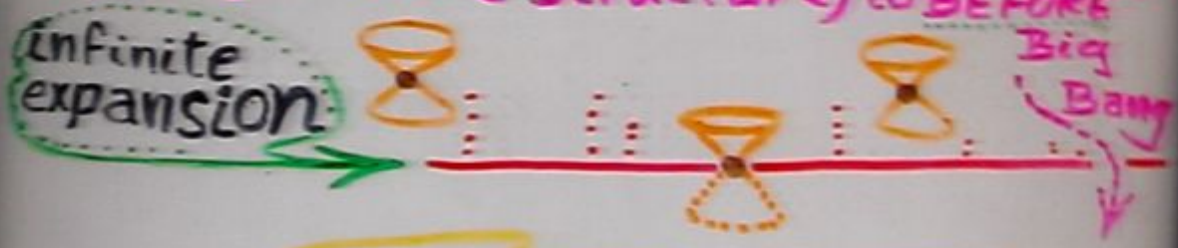

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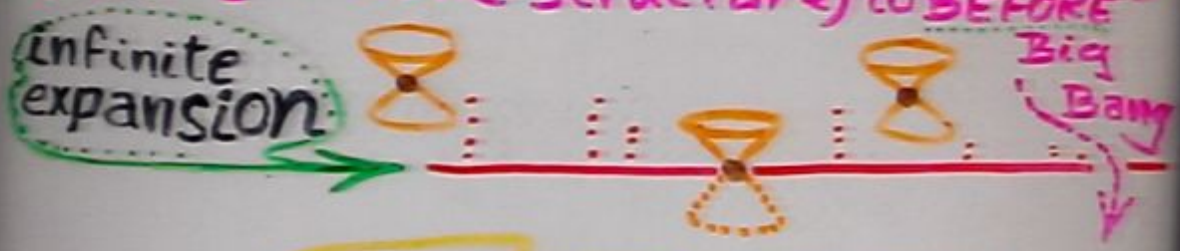

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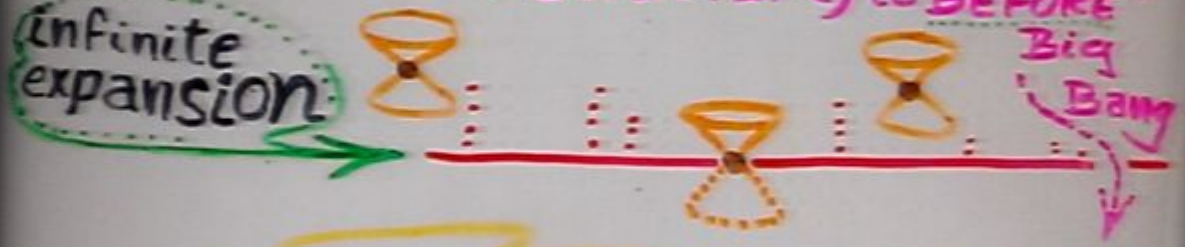

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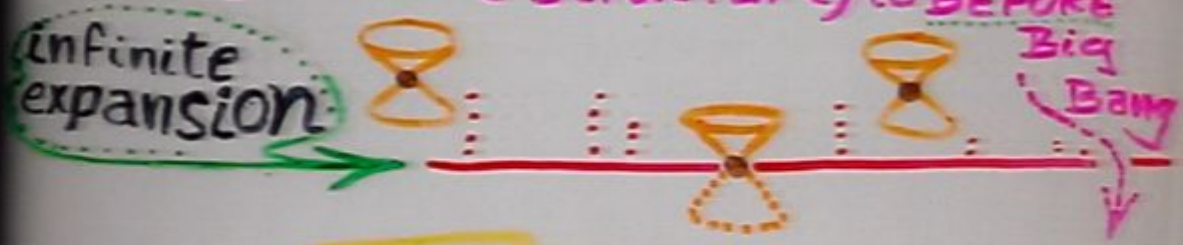

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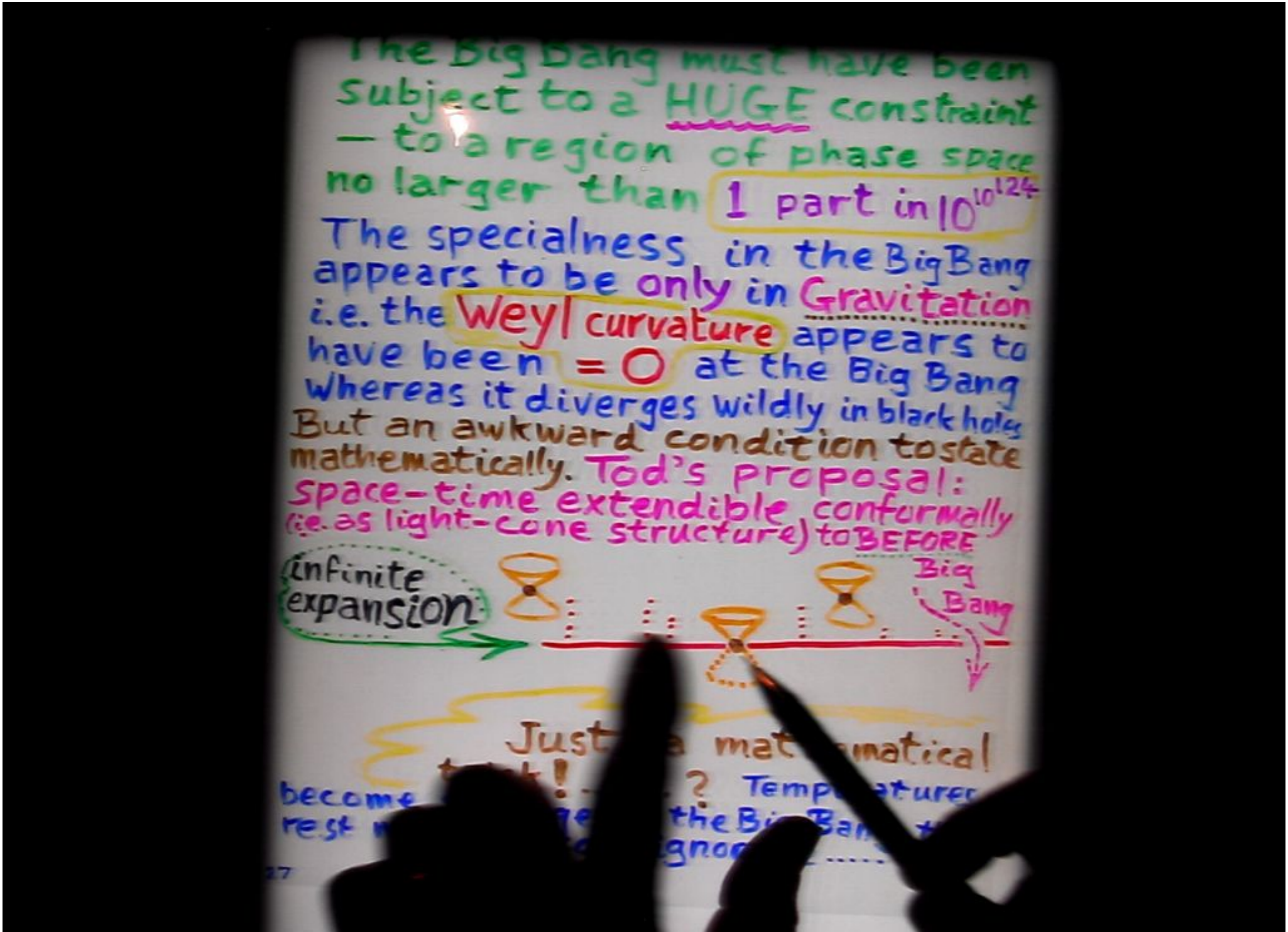
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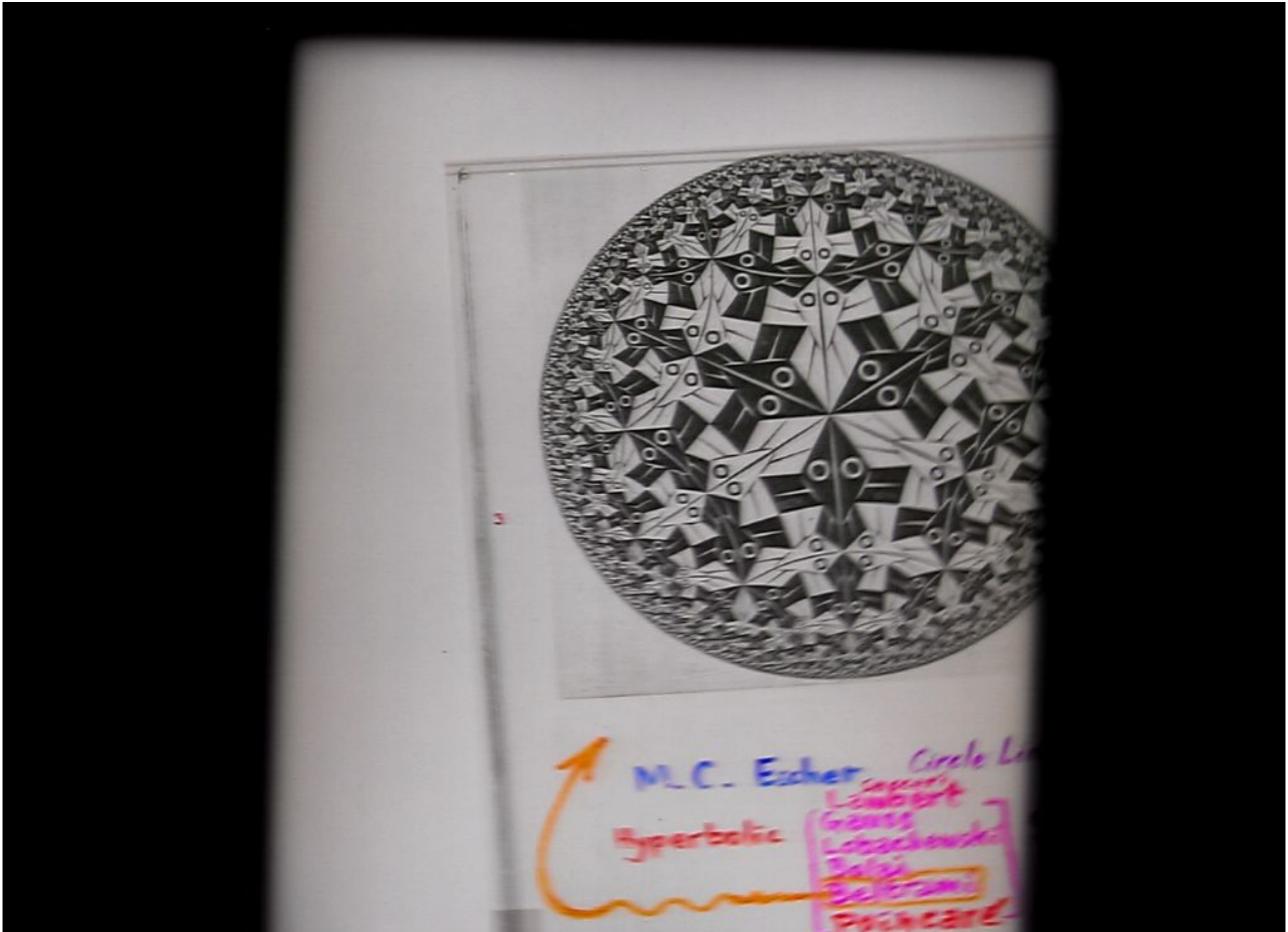
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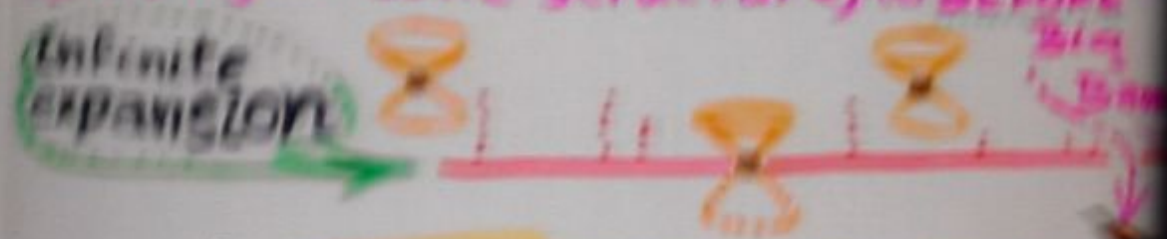

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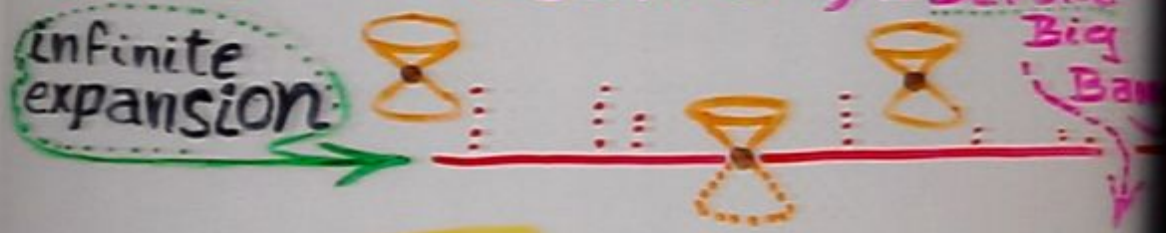

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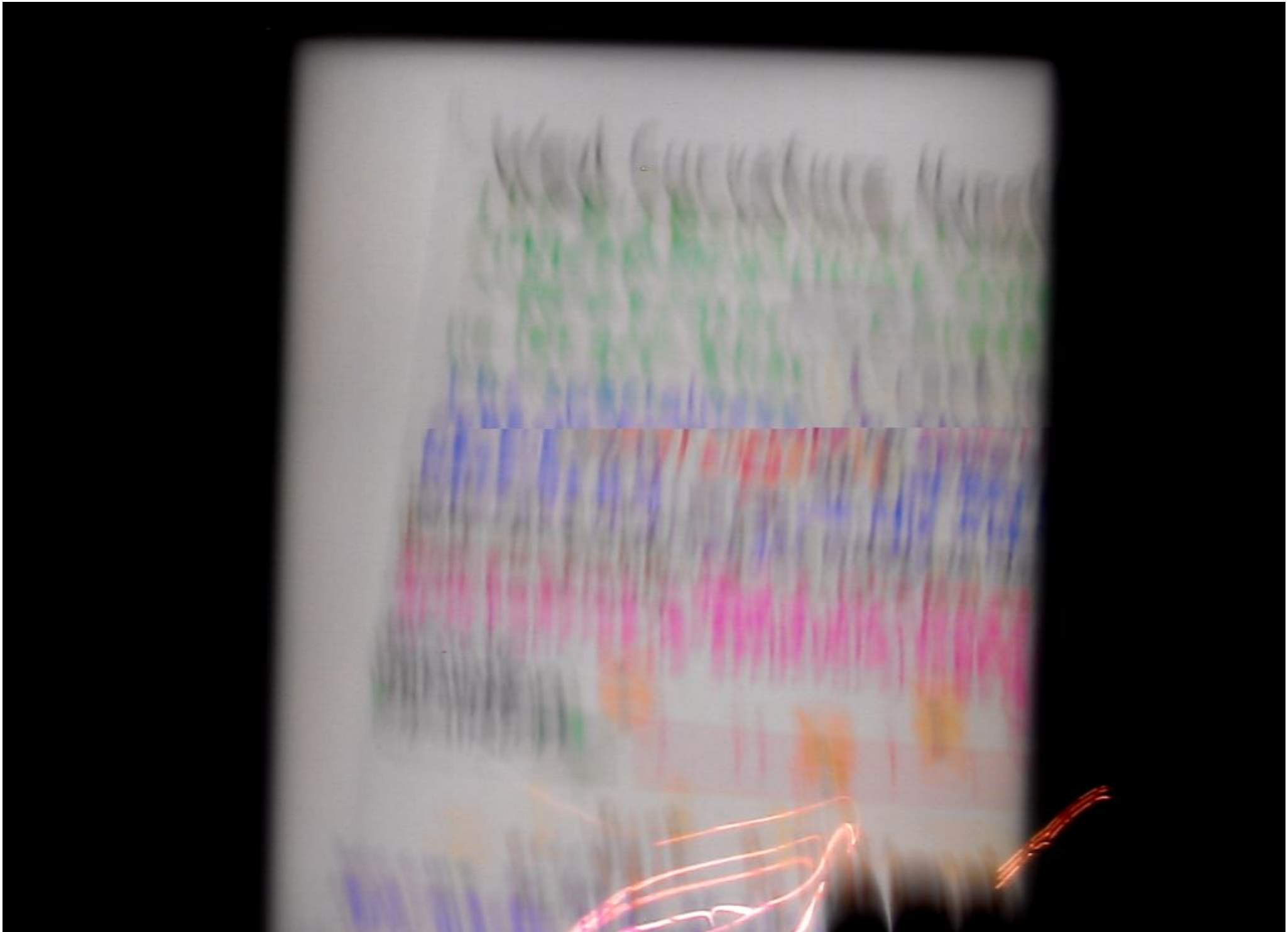

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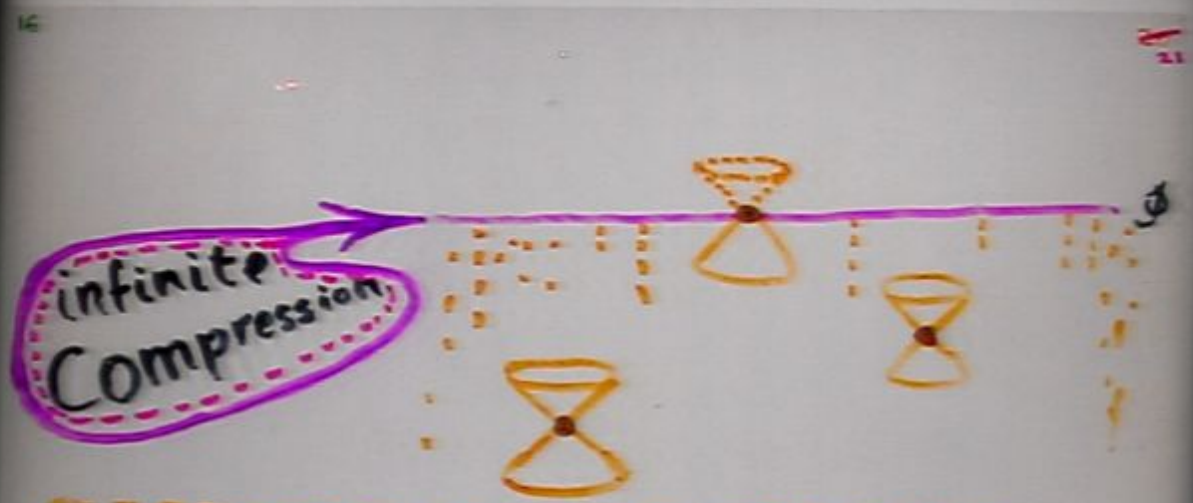
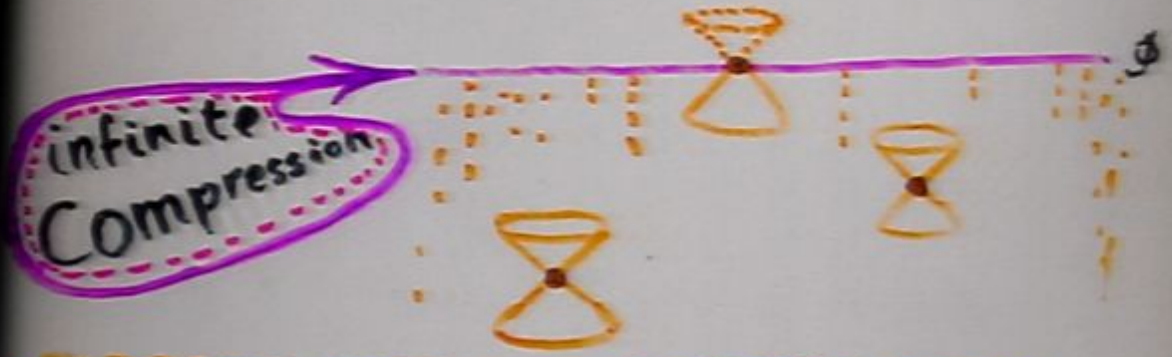


The extemely remote future

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



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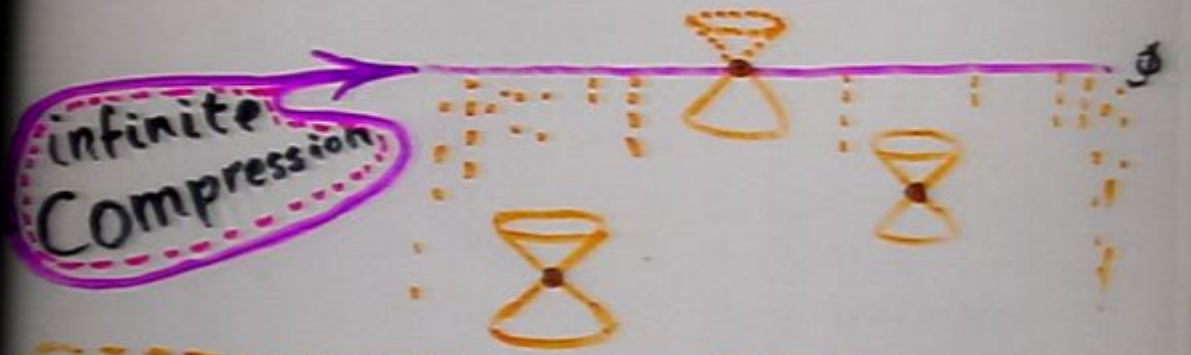

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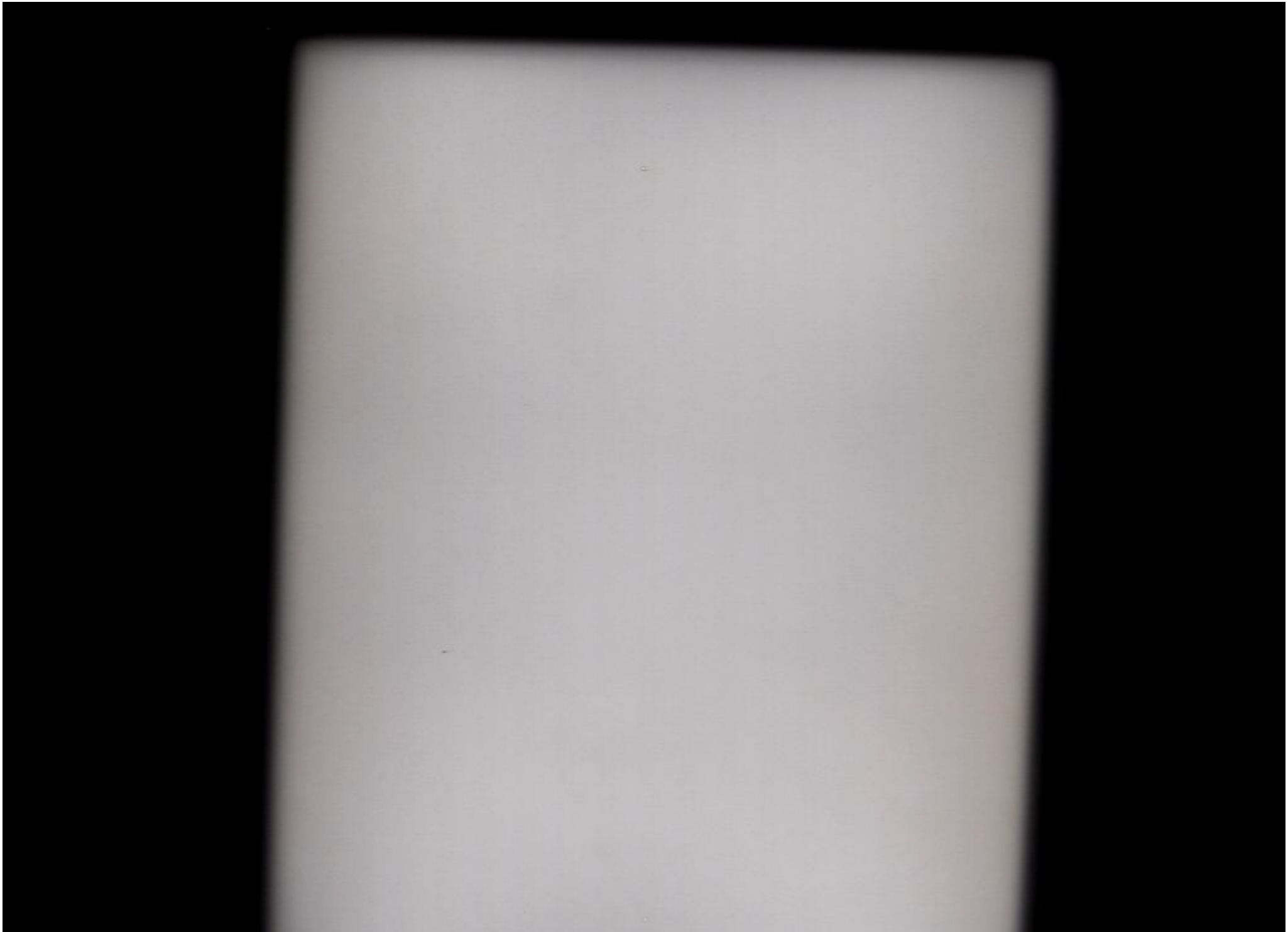

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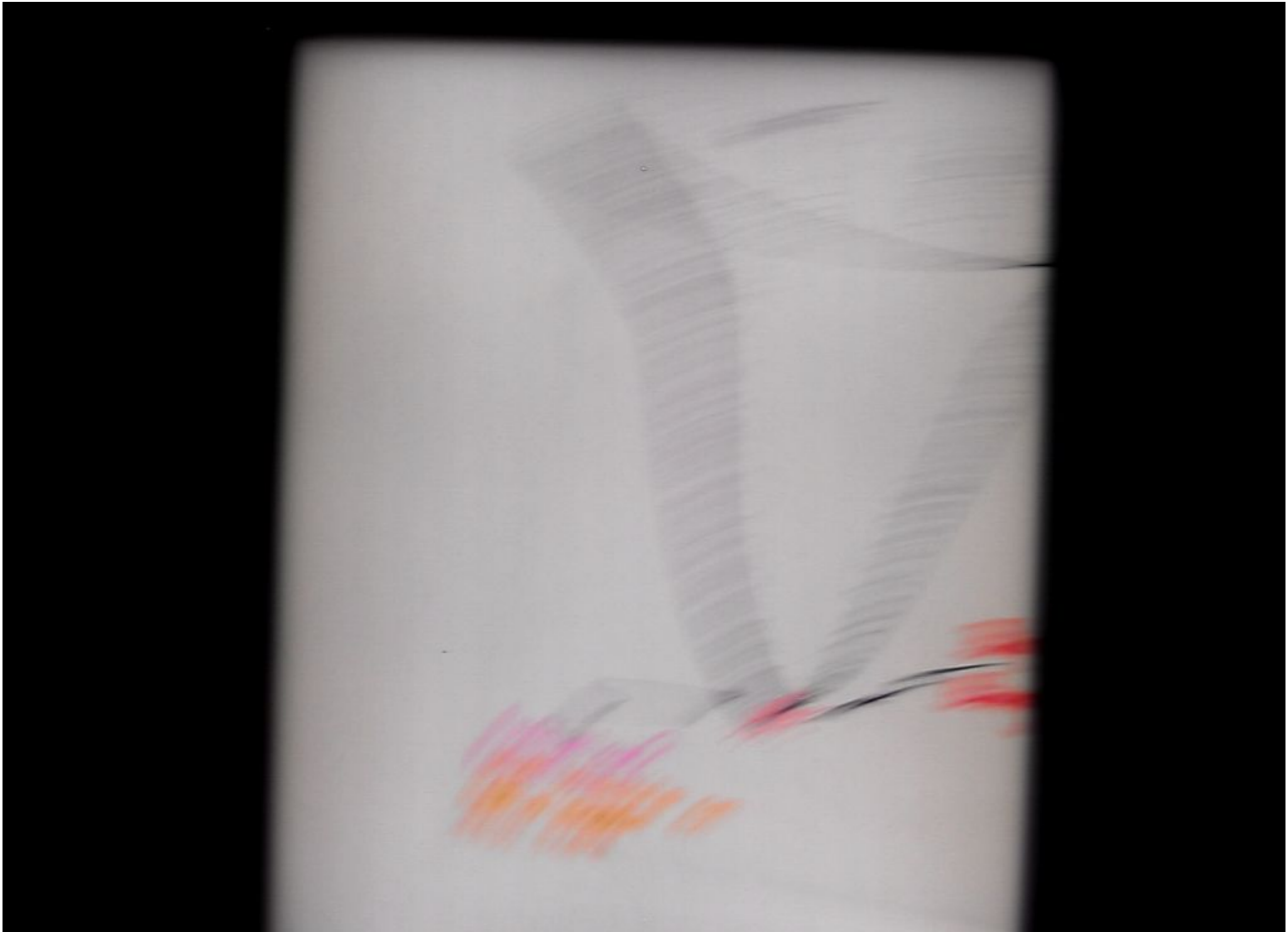

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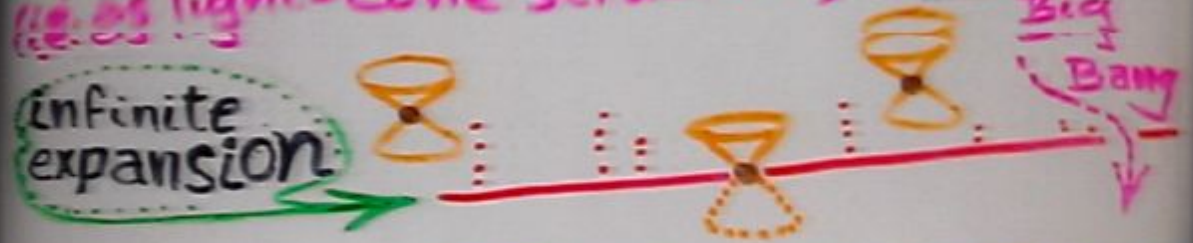

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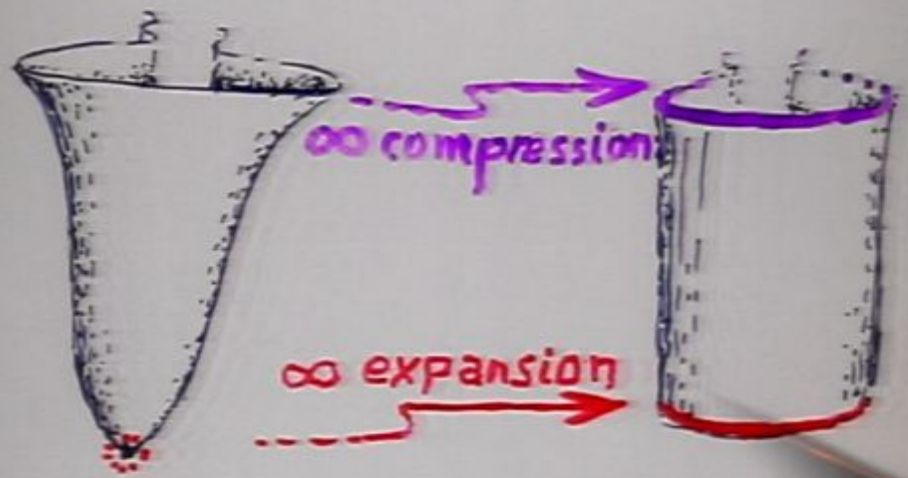
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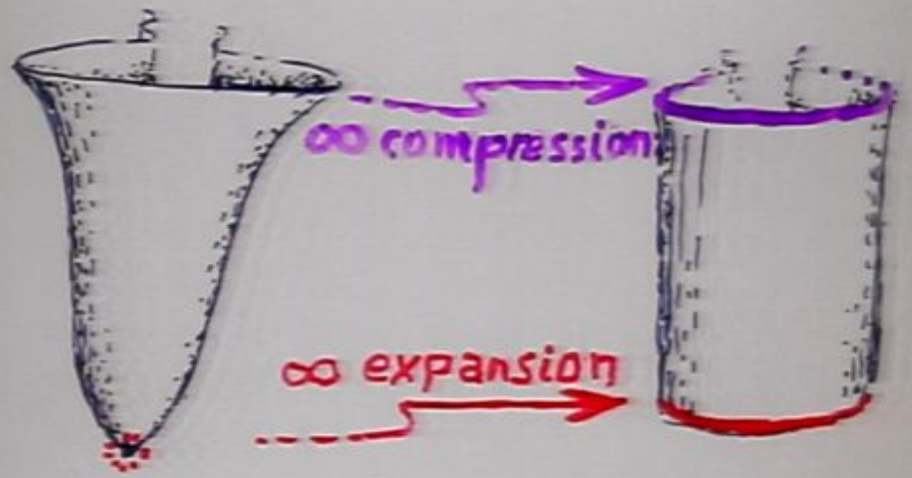
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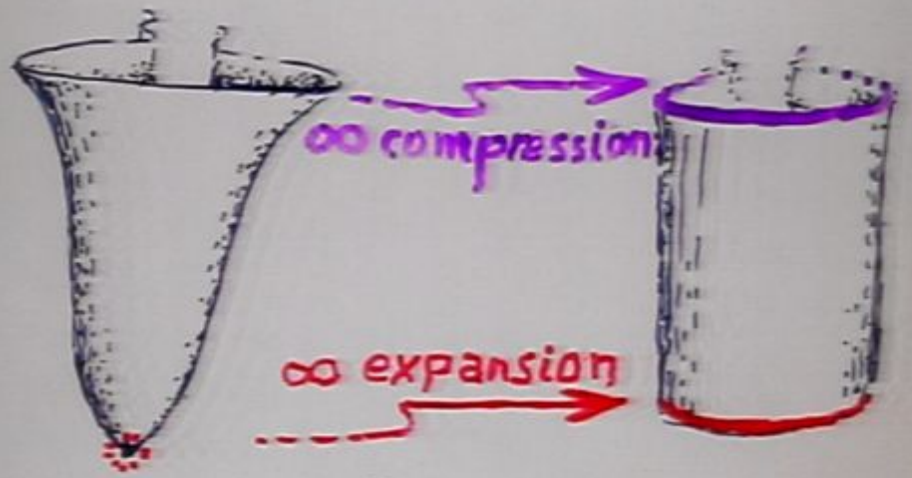
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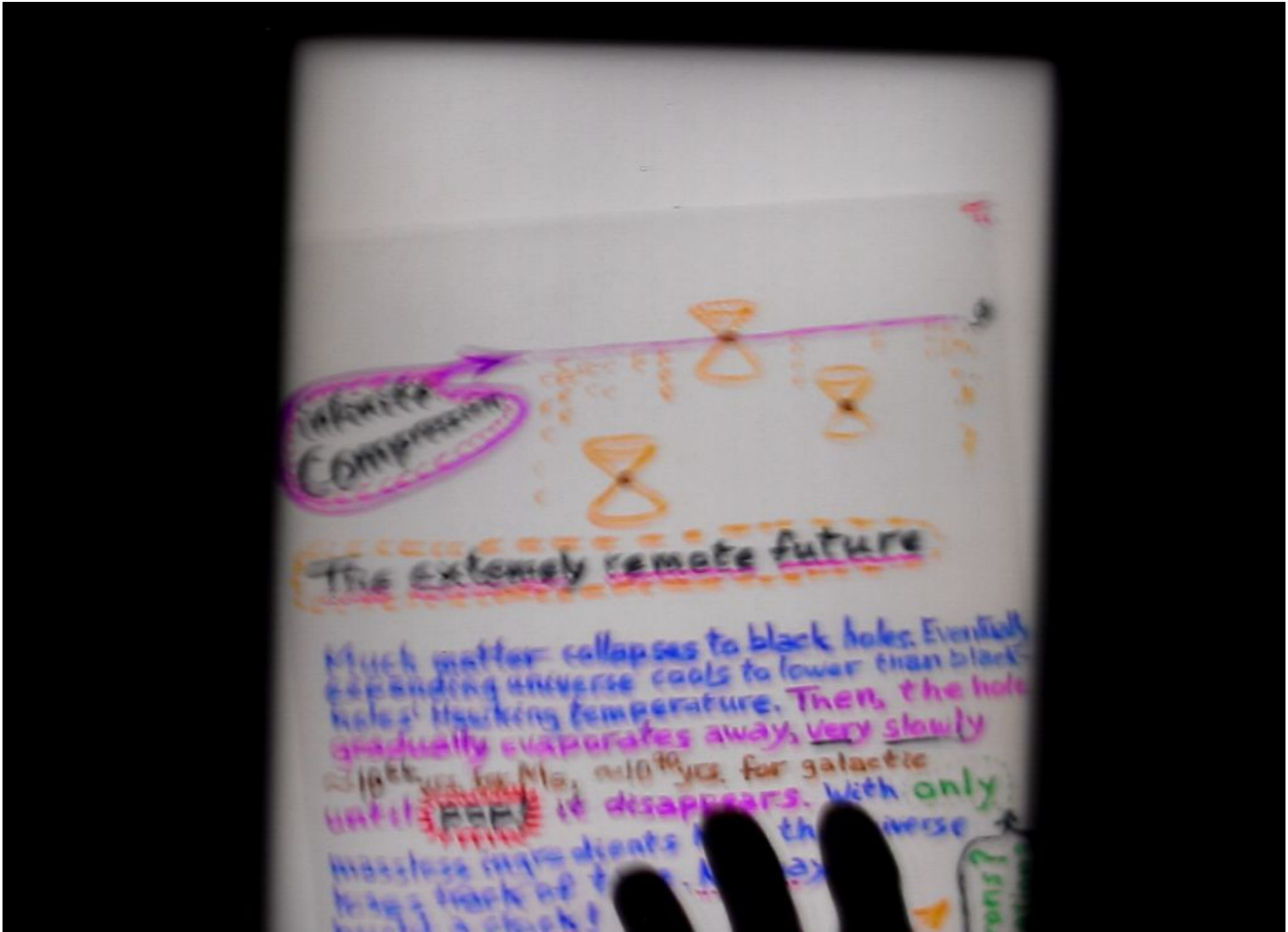
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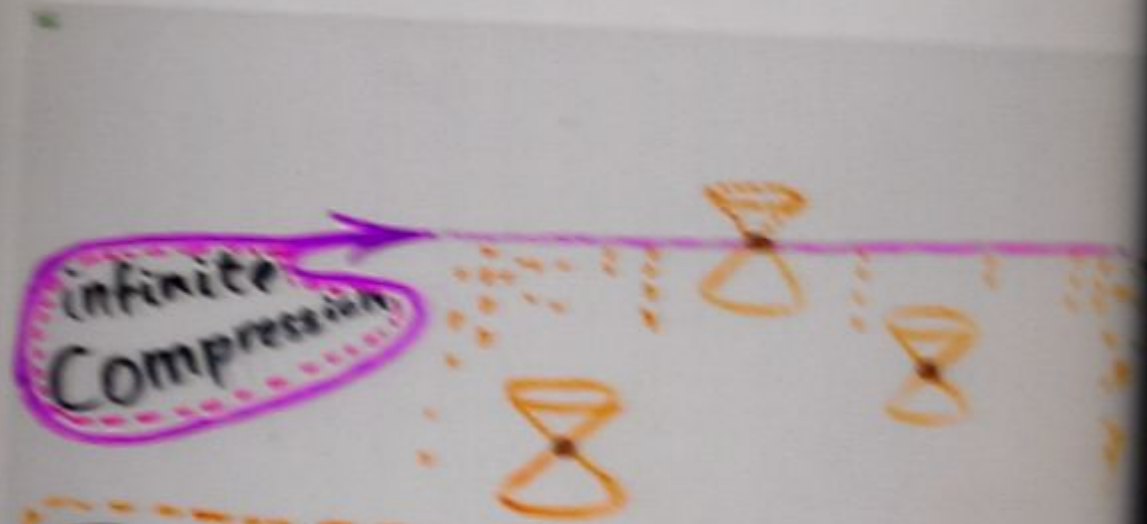

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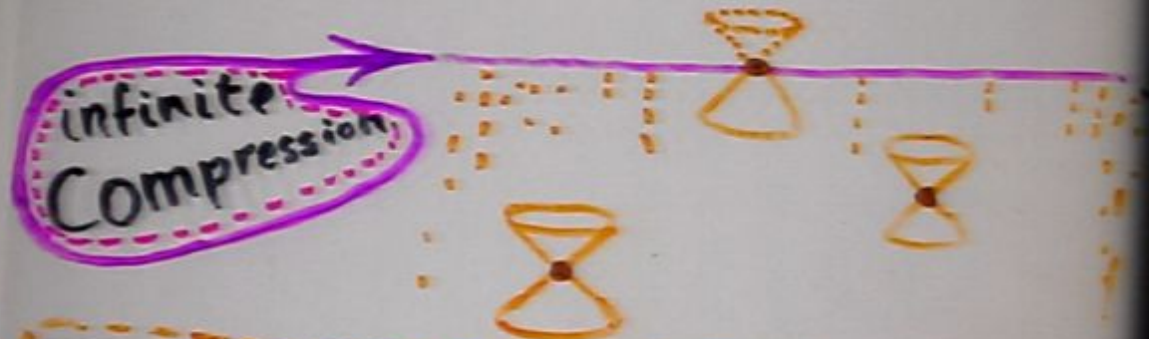

The extemely remote future

Much matter collapses to black holes. Eventu
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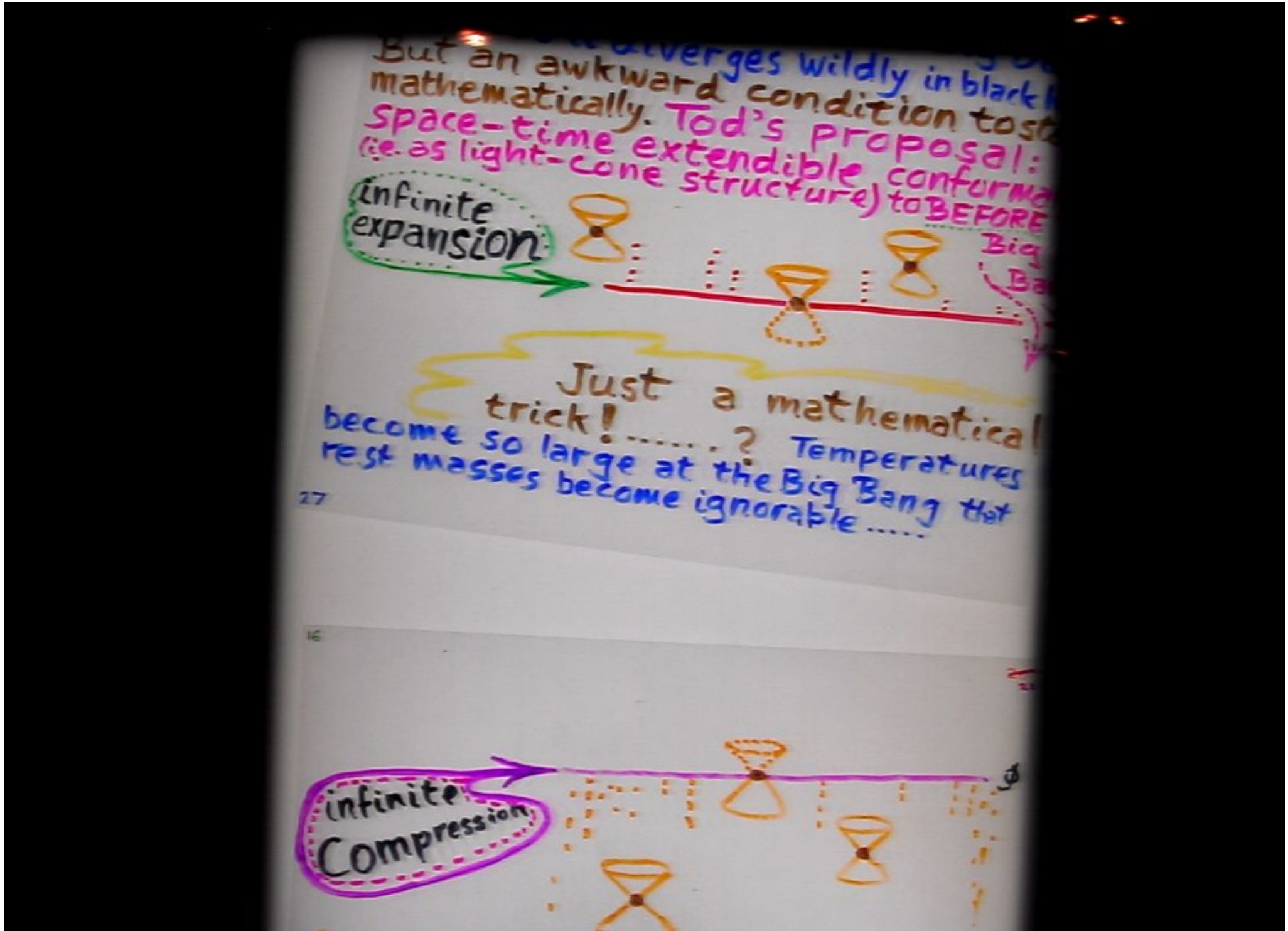
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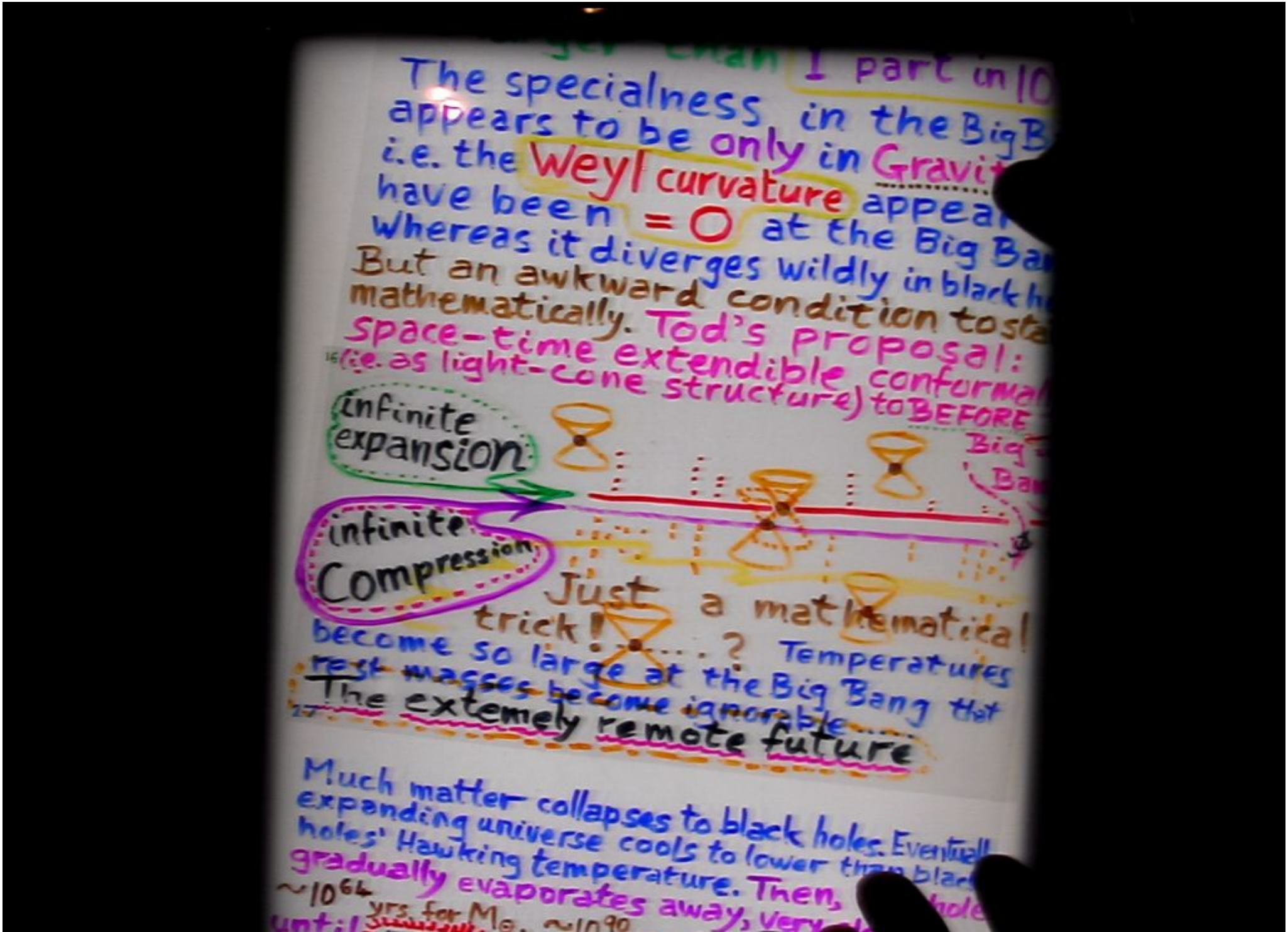
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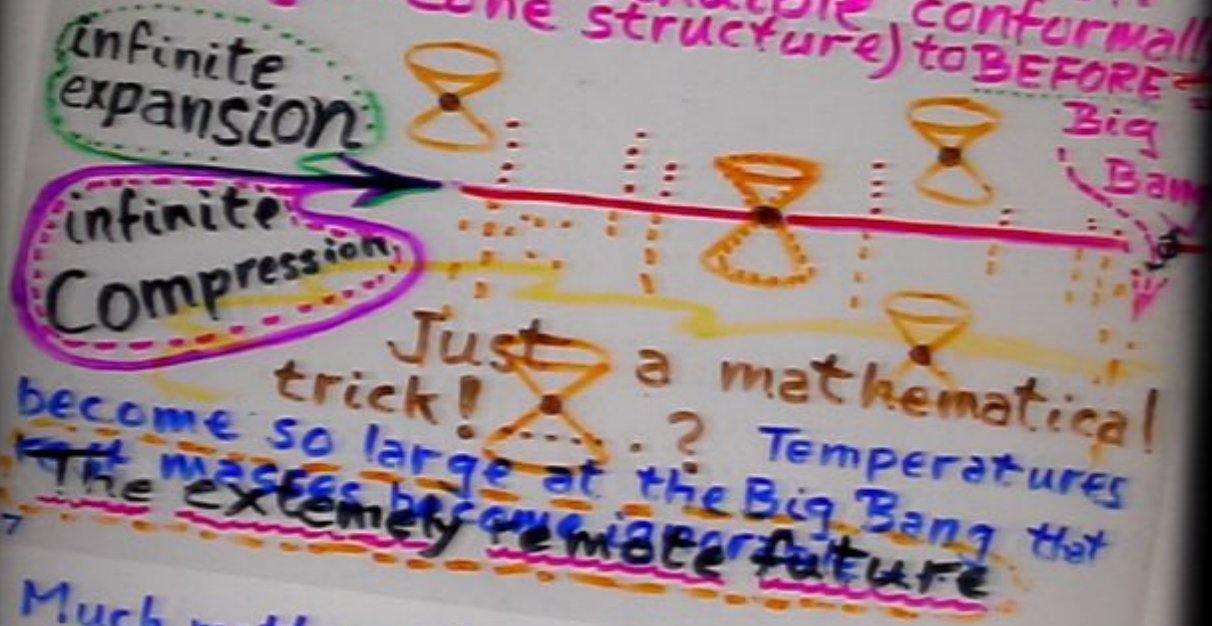

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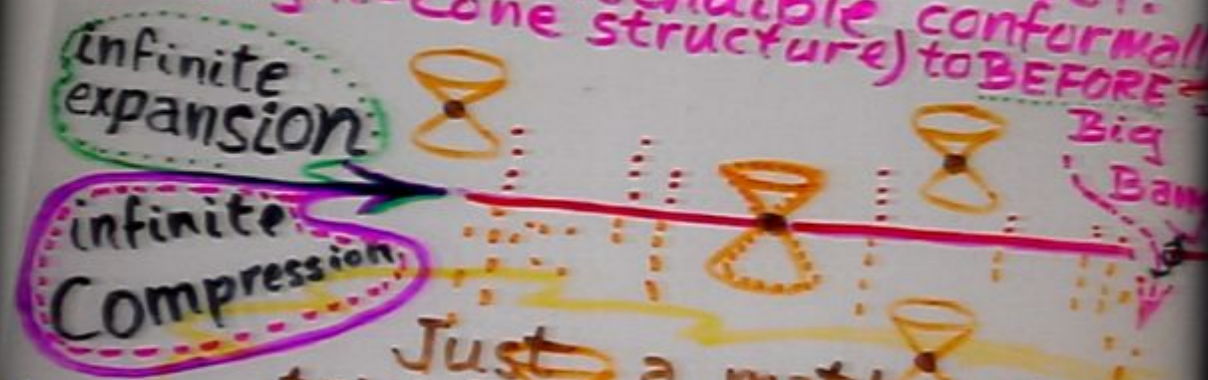

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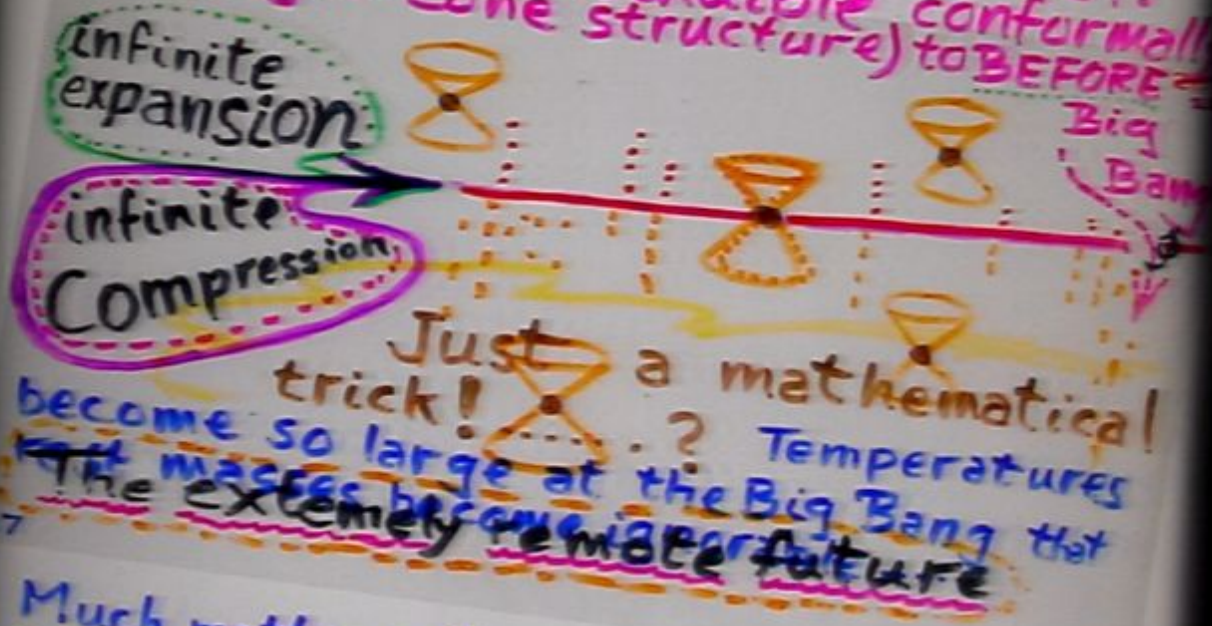

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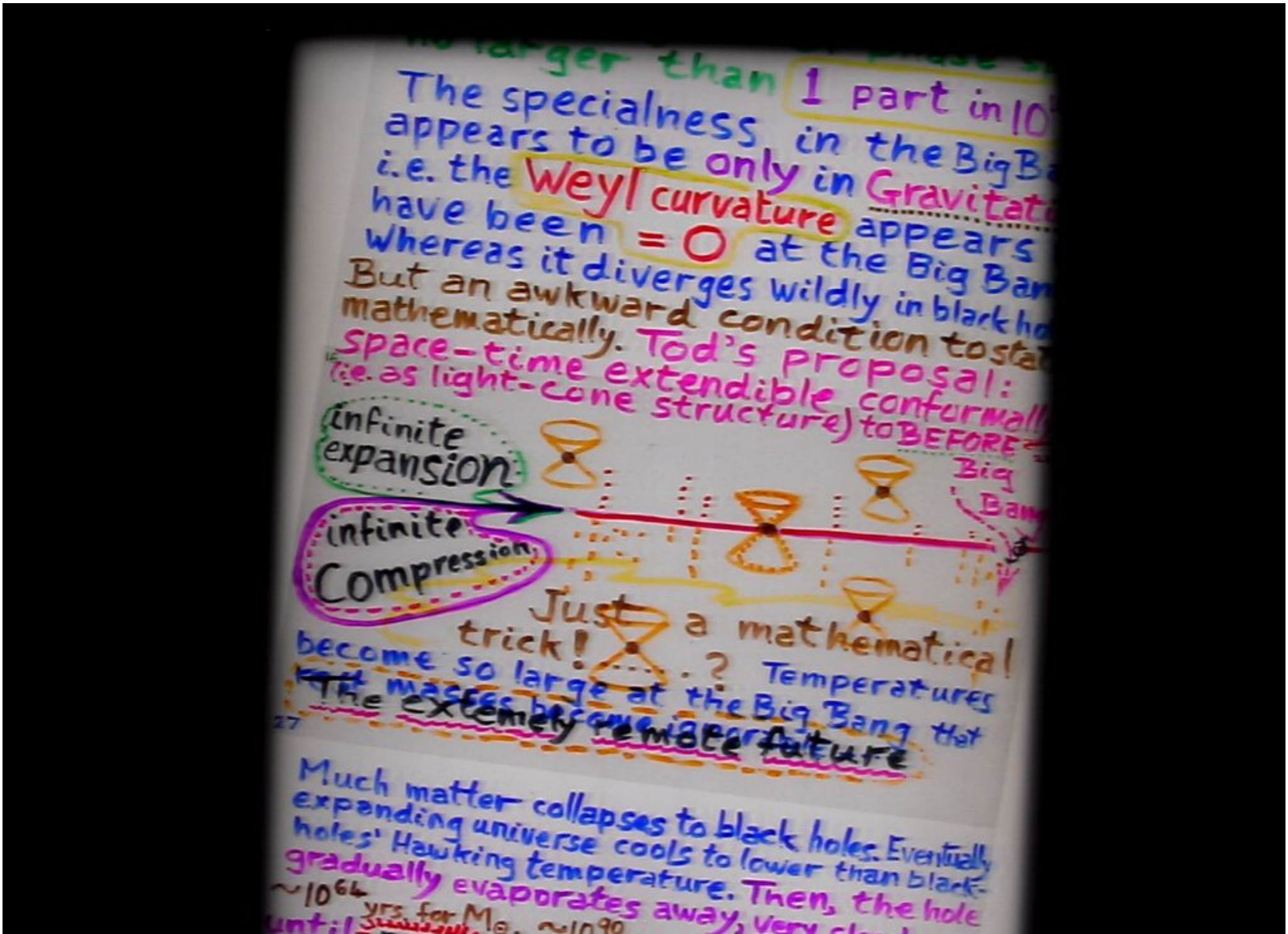

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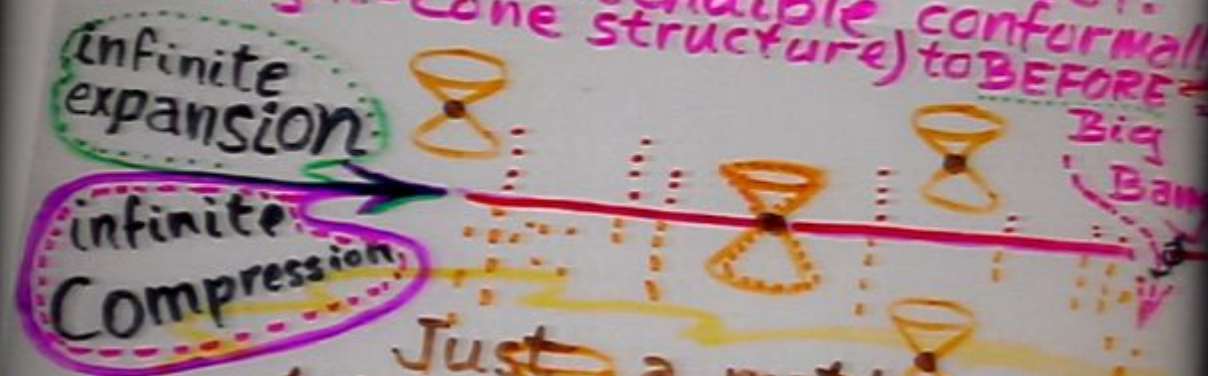

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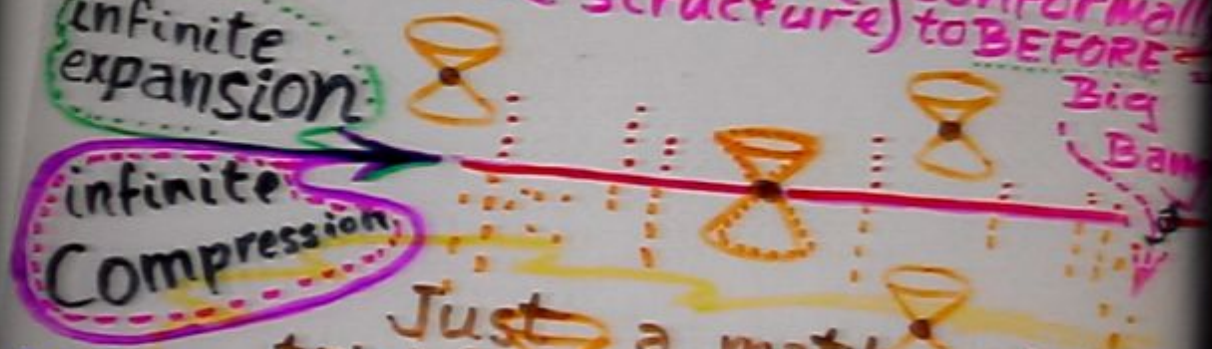

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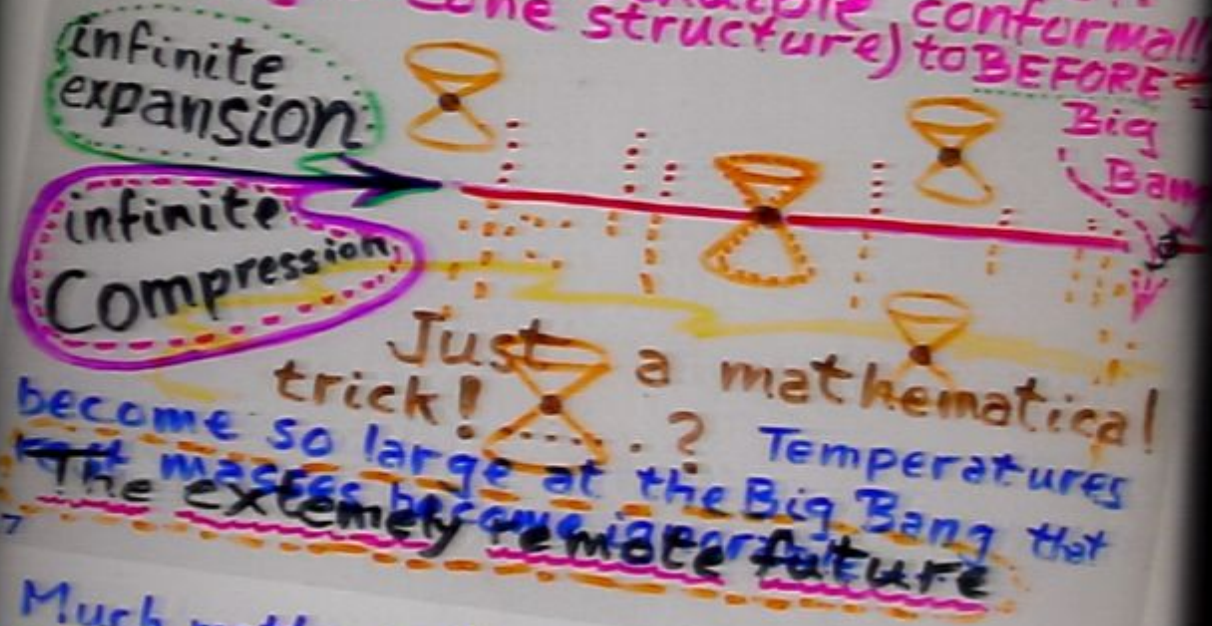

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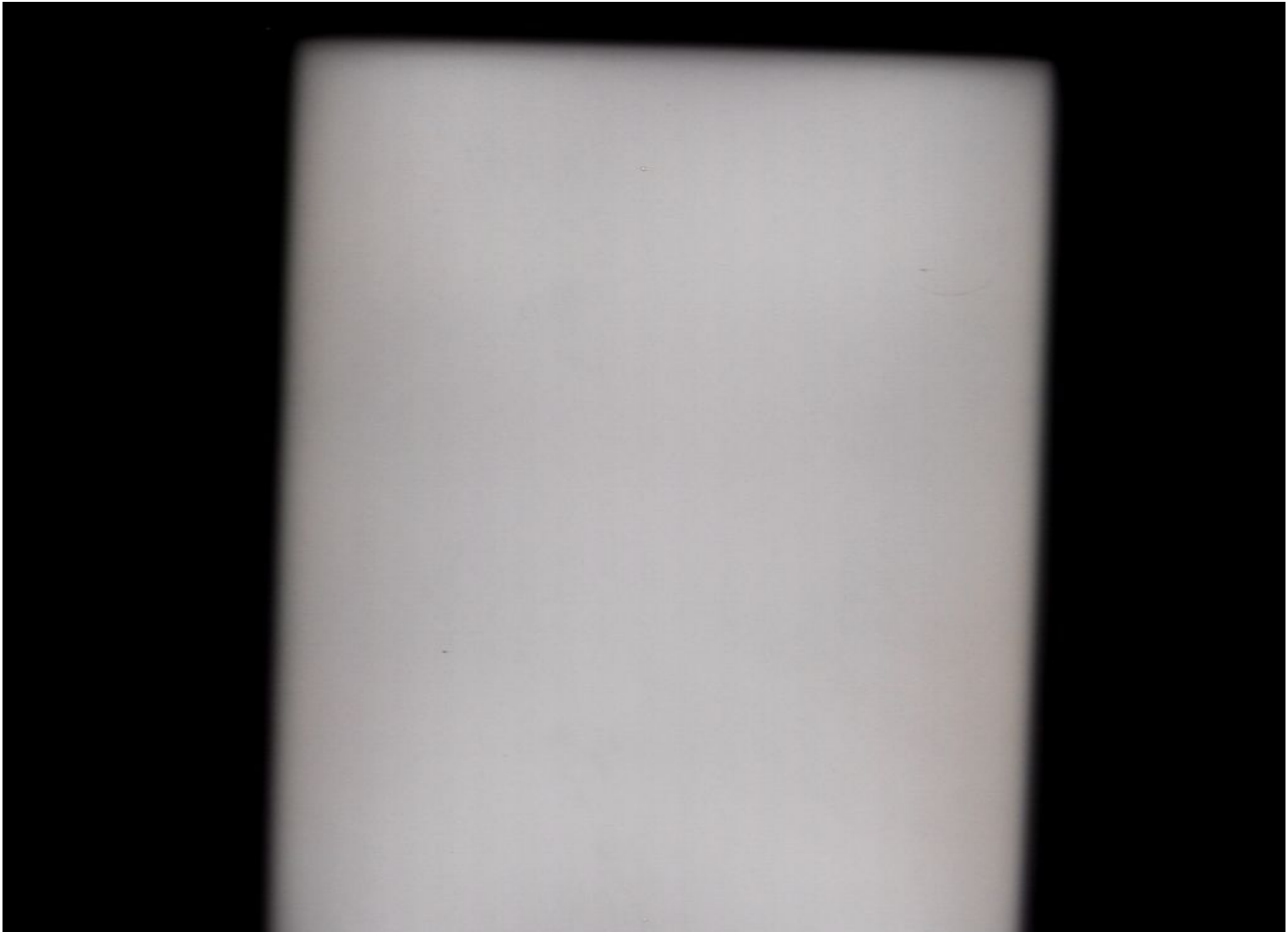

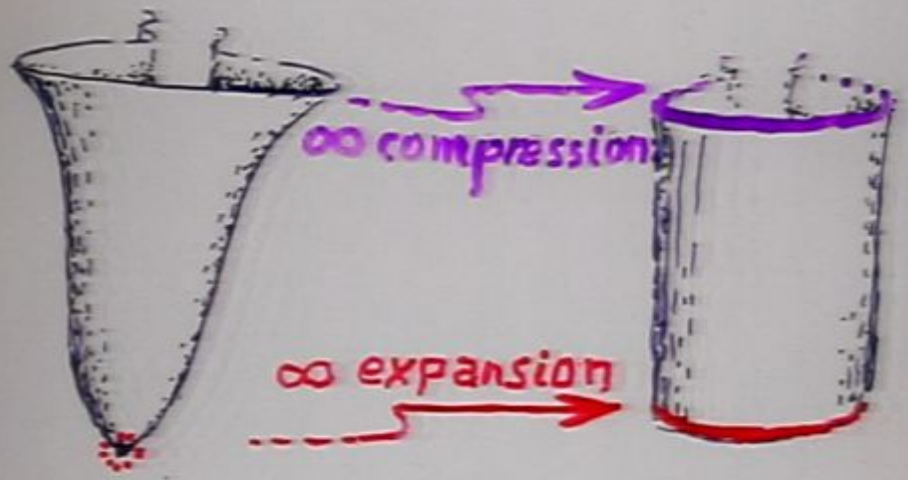
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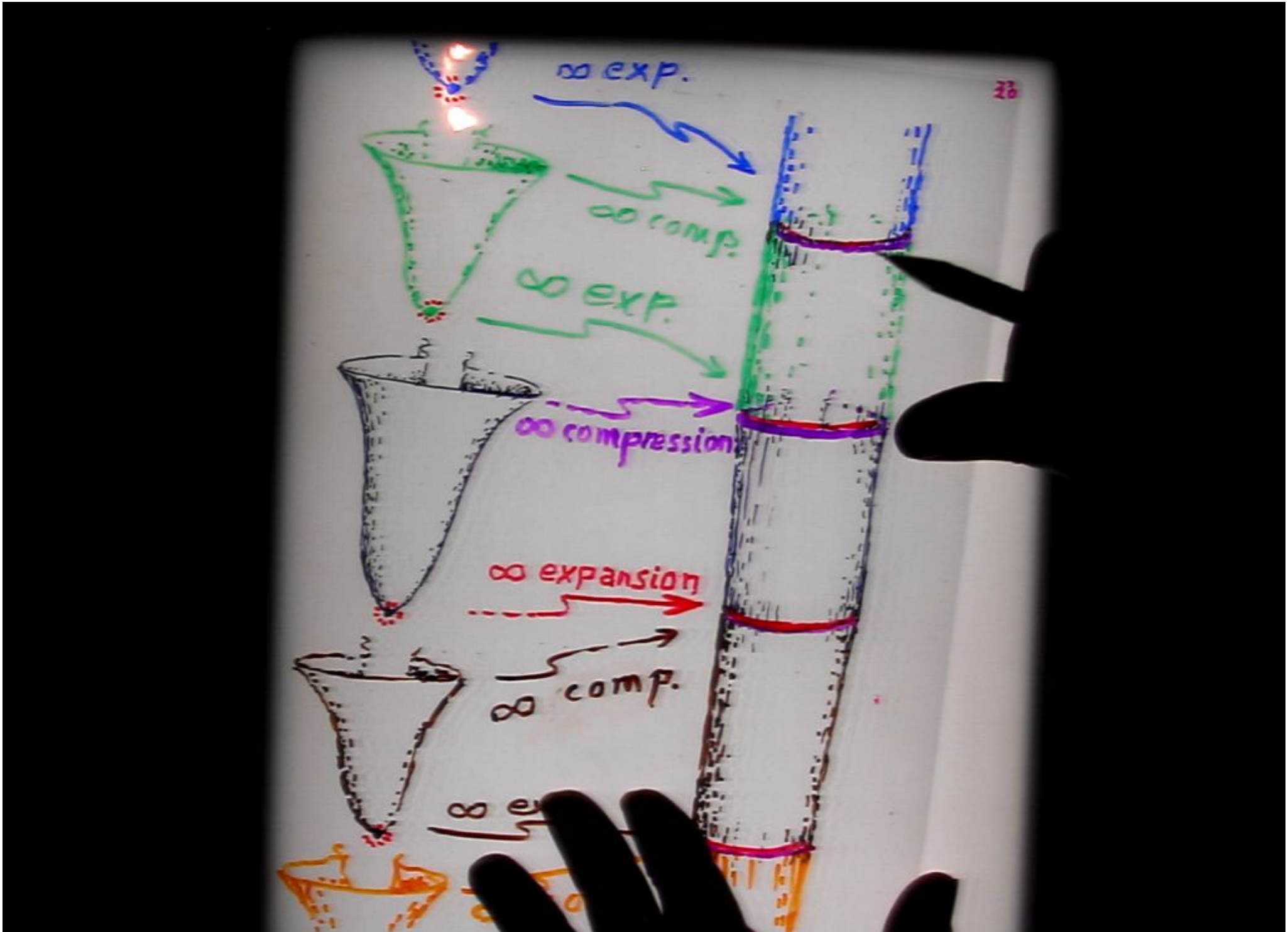
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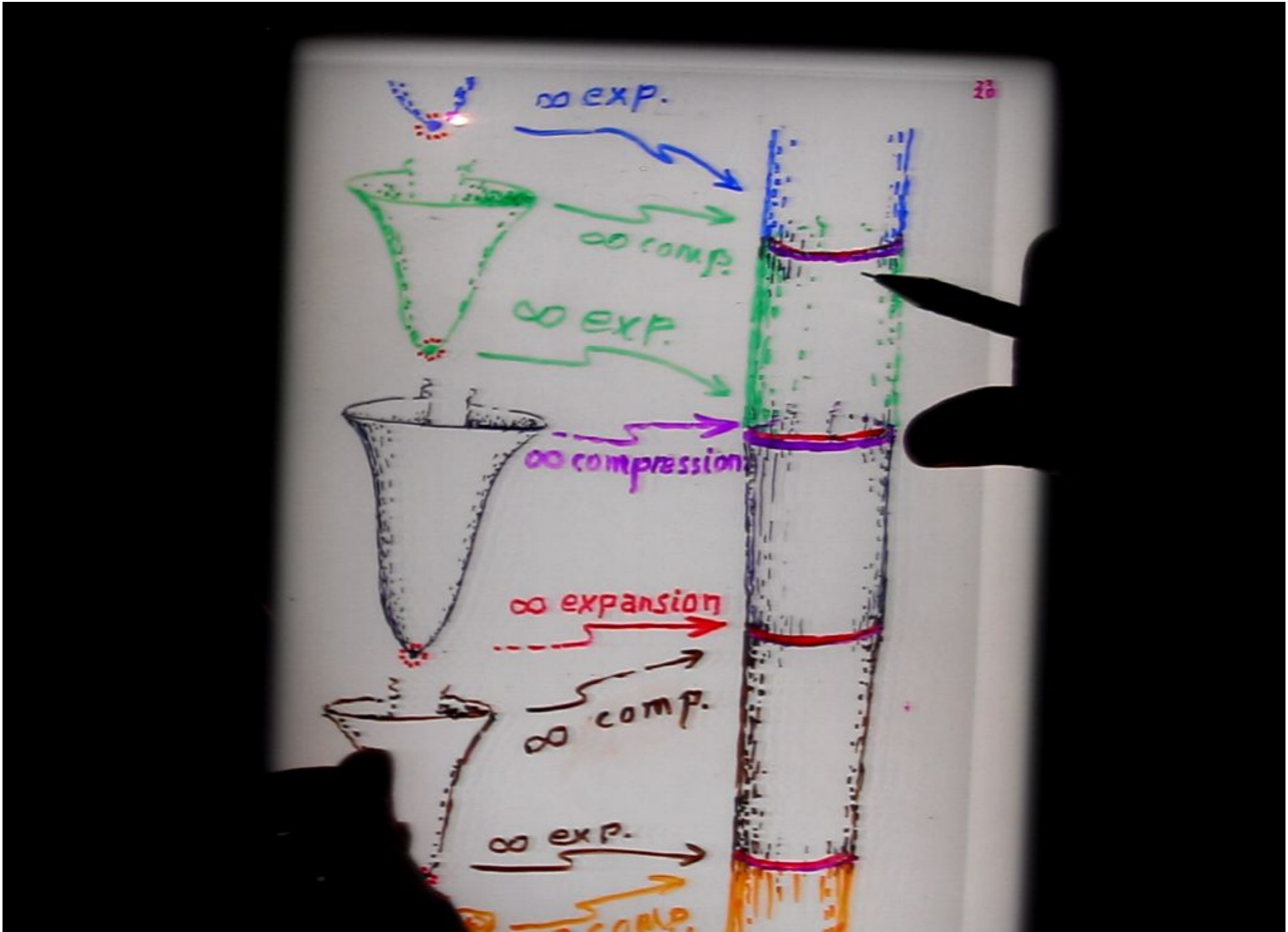
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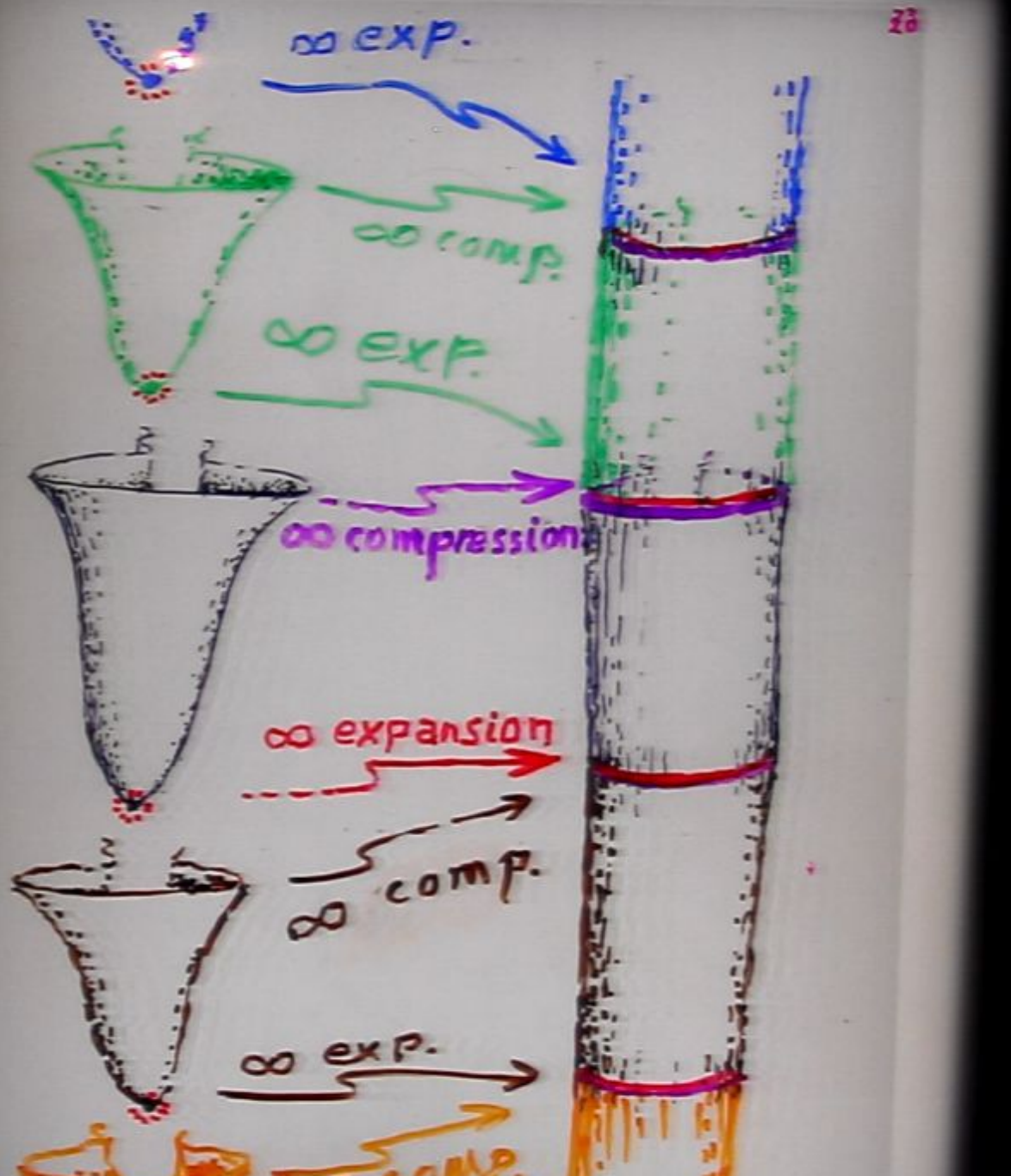
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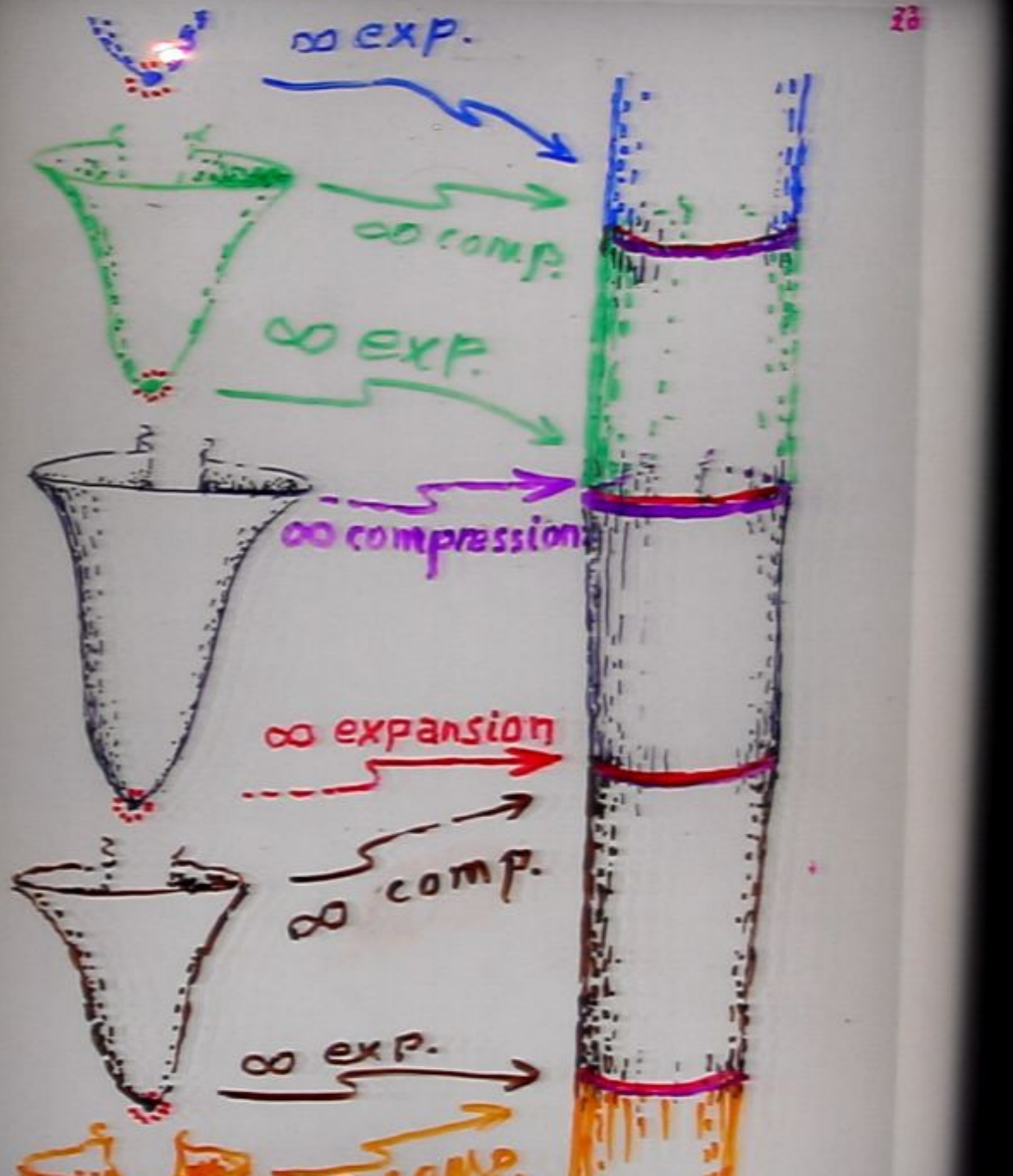
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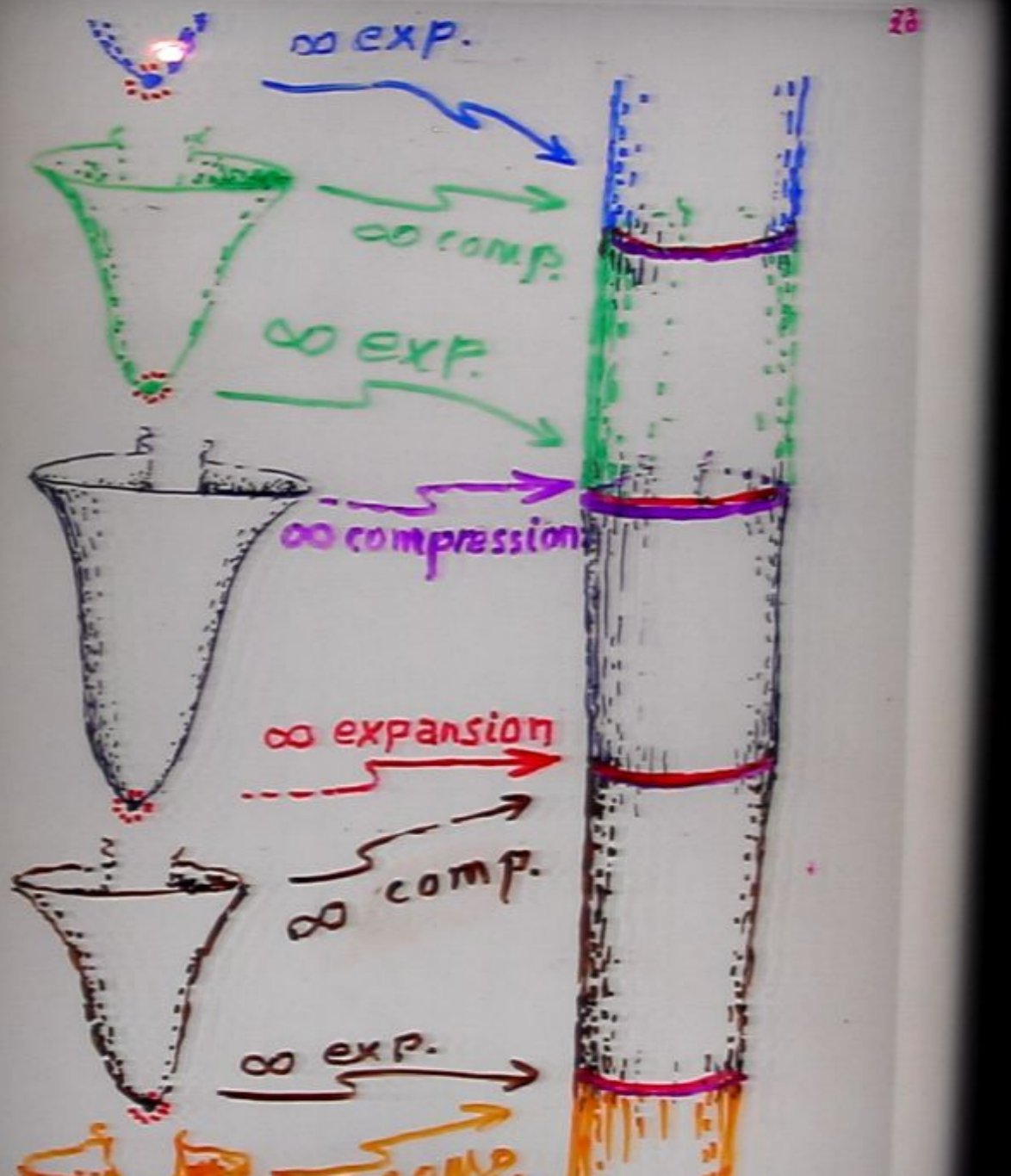
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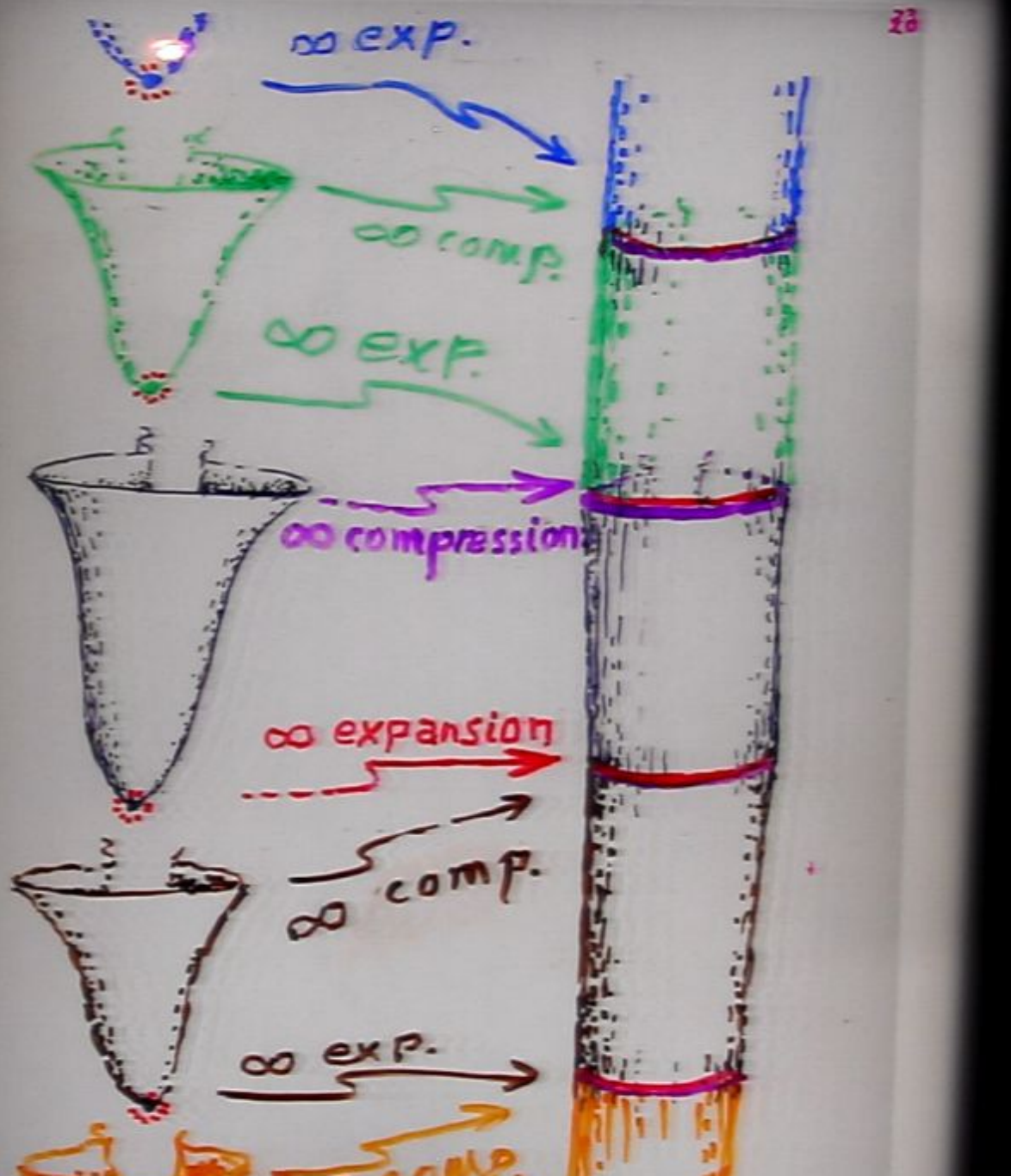
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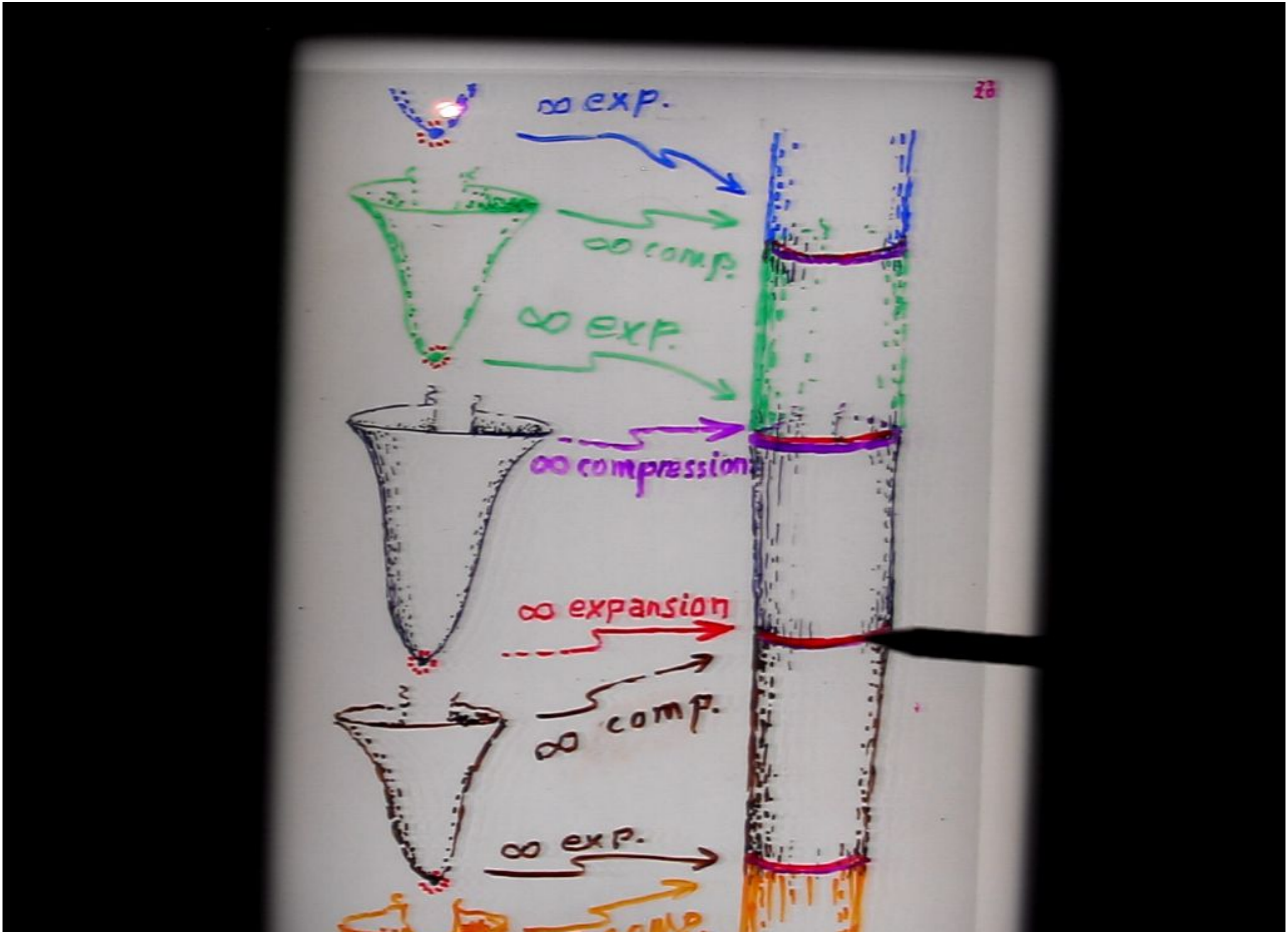
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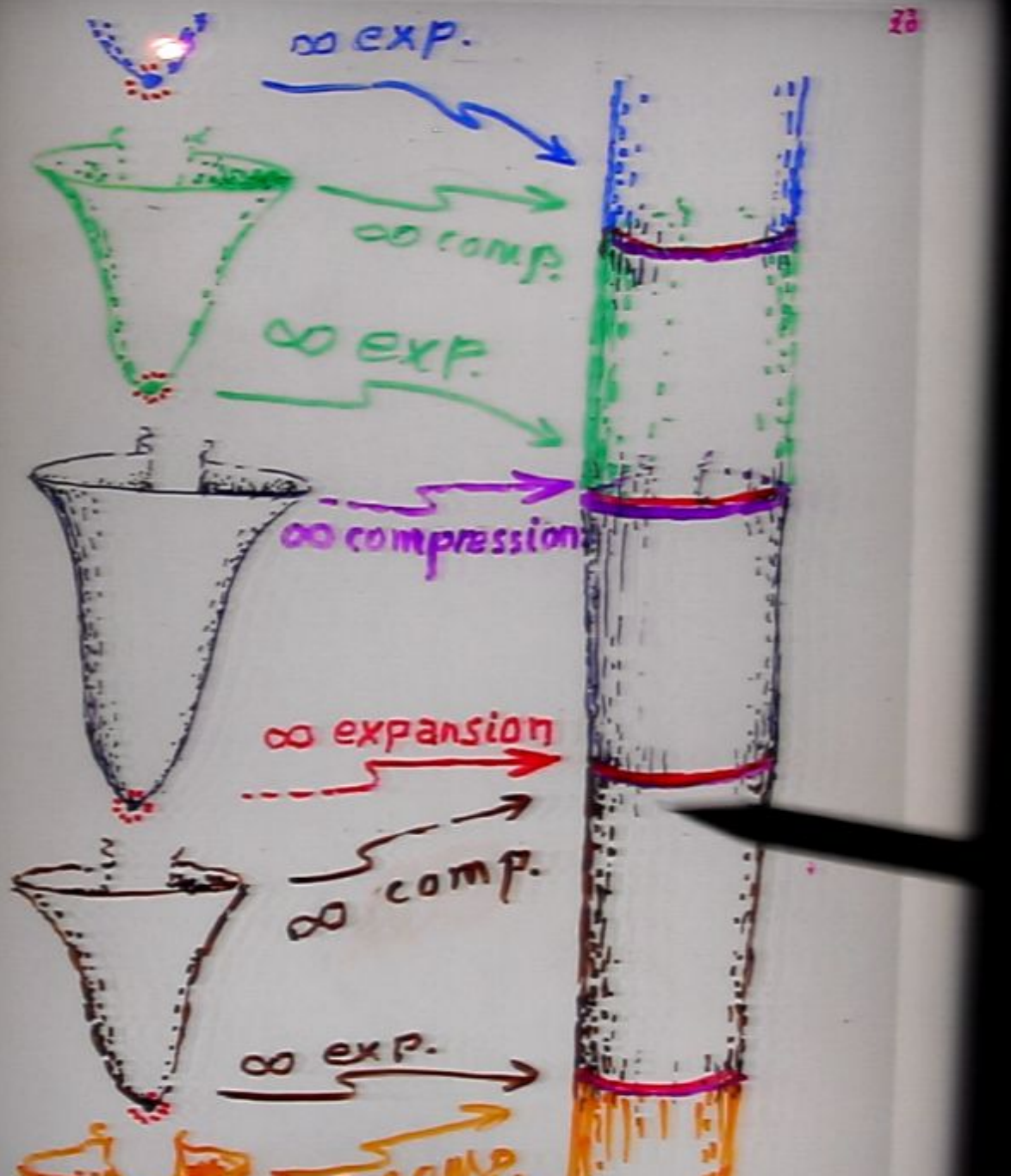
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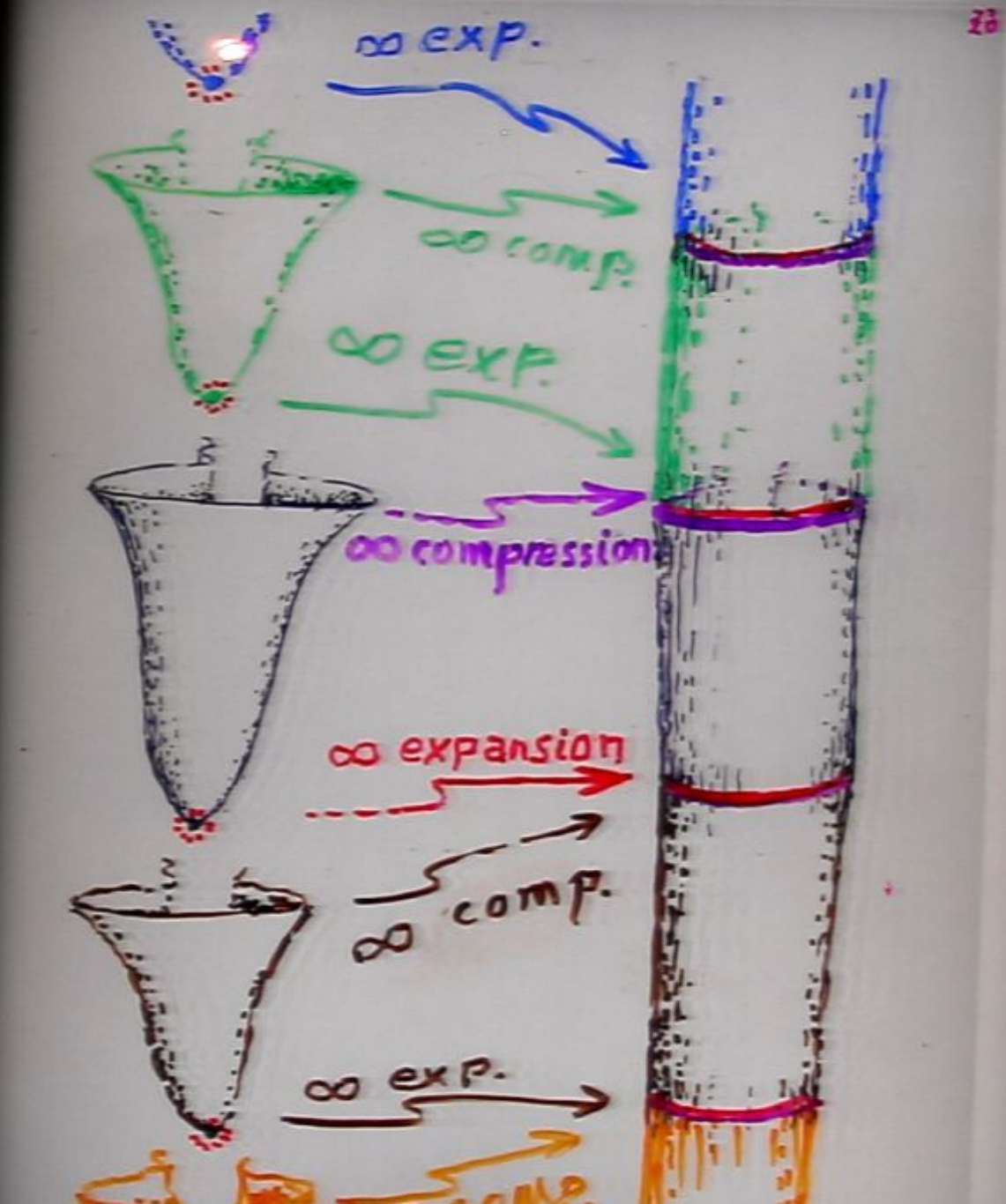
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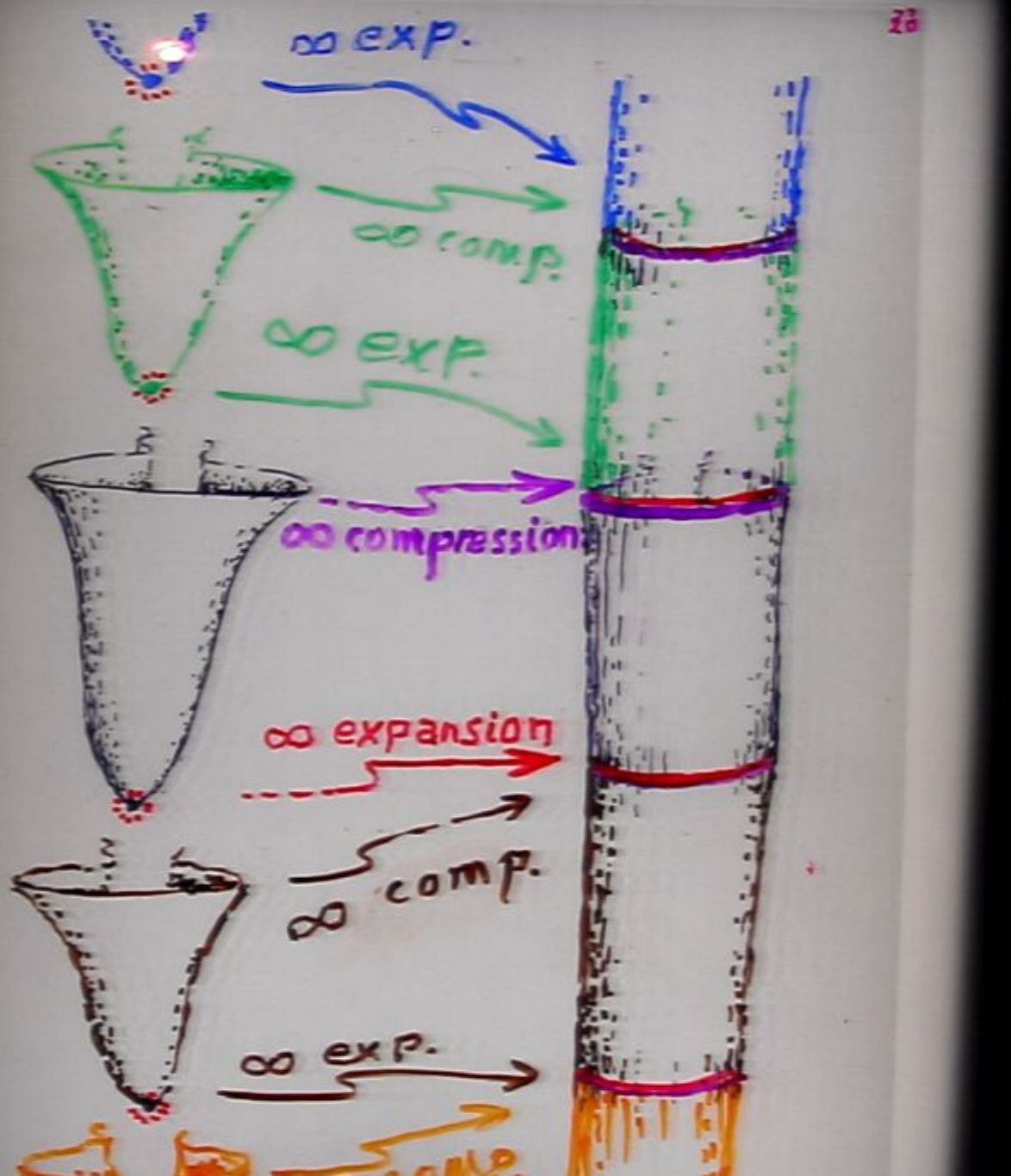
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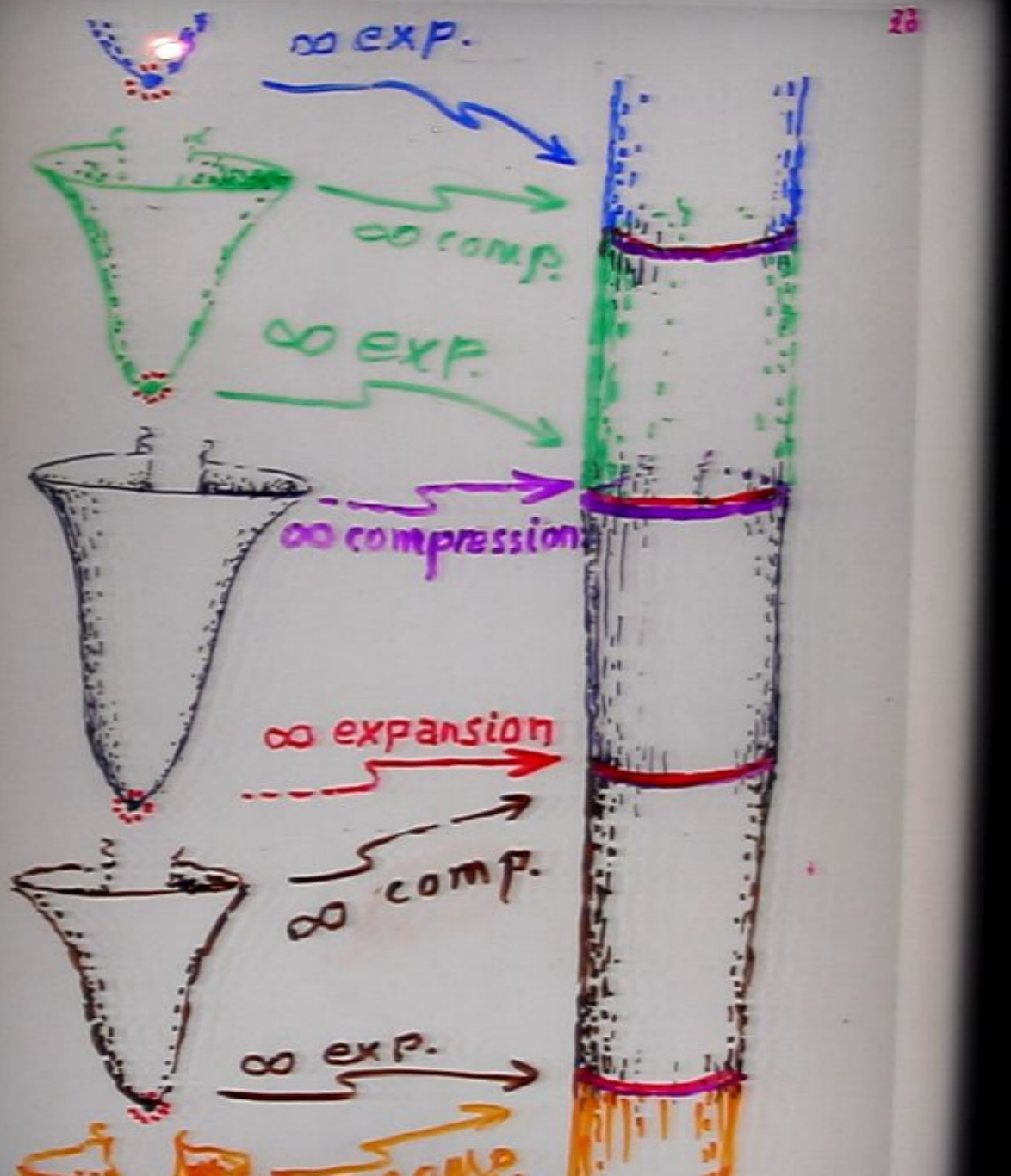
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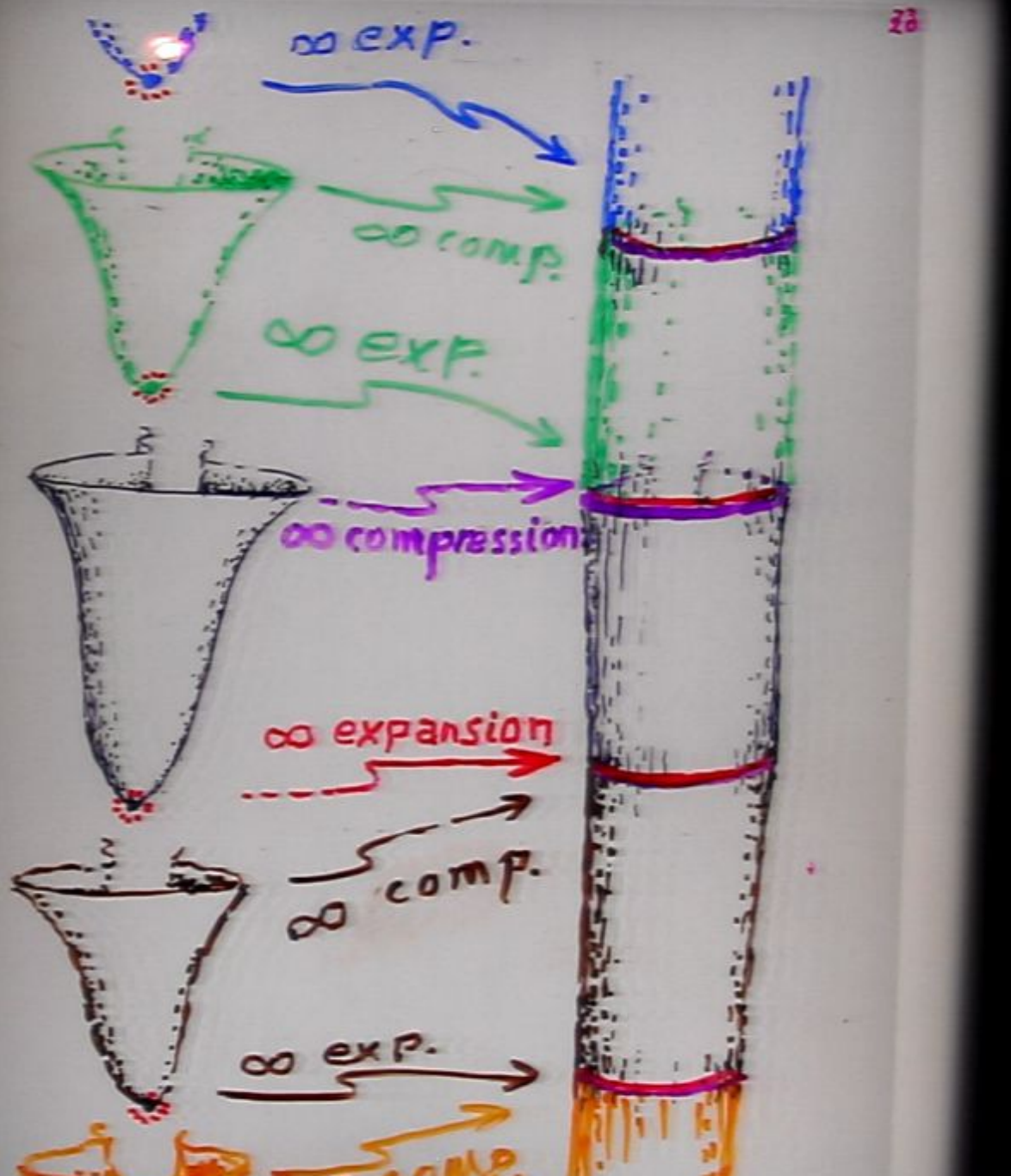
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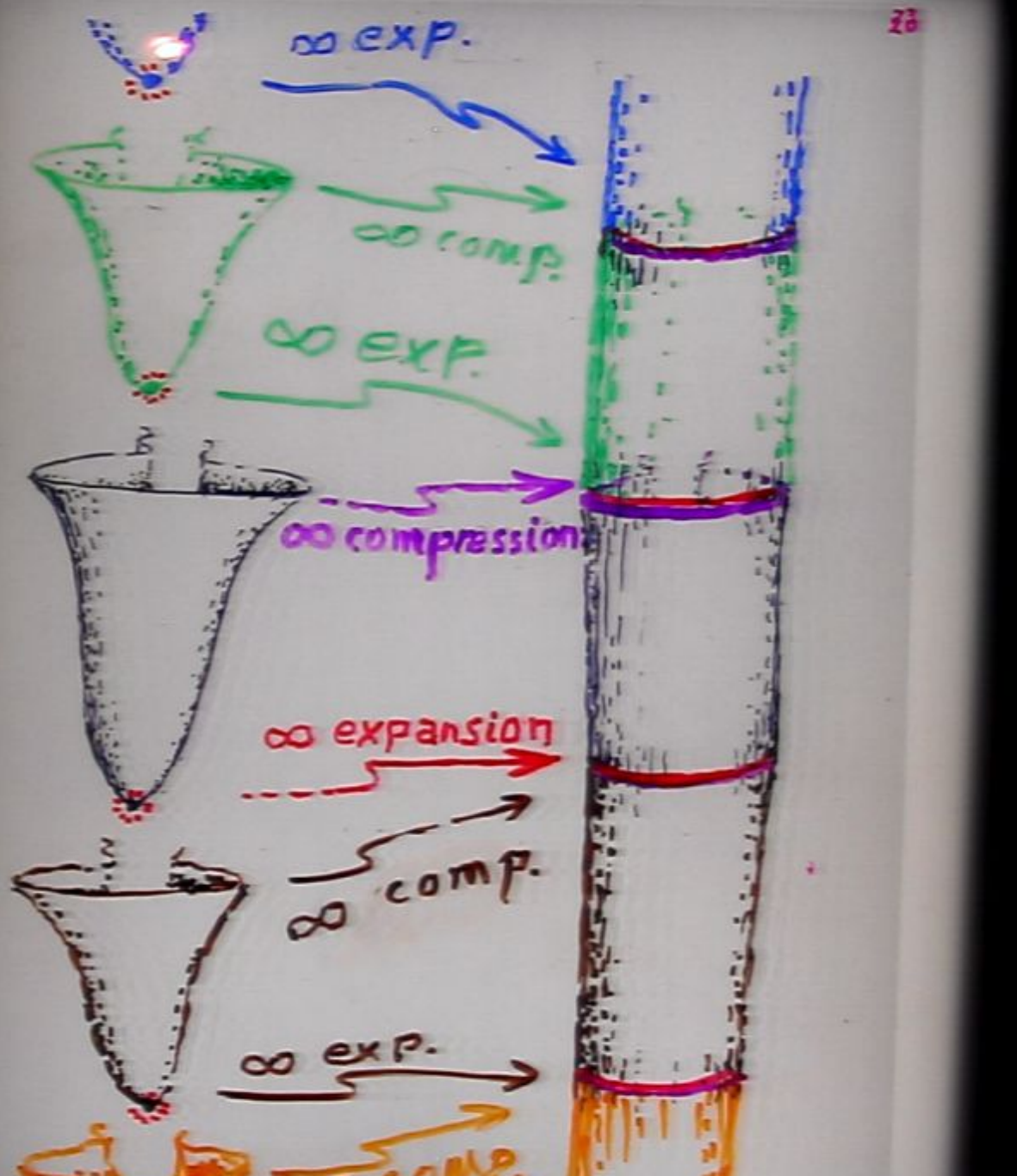
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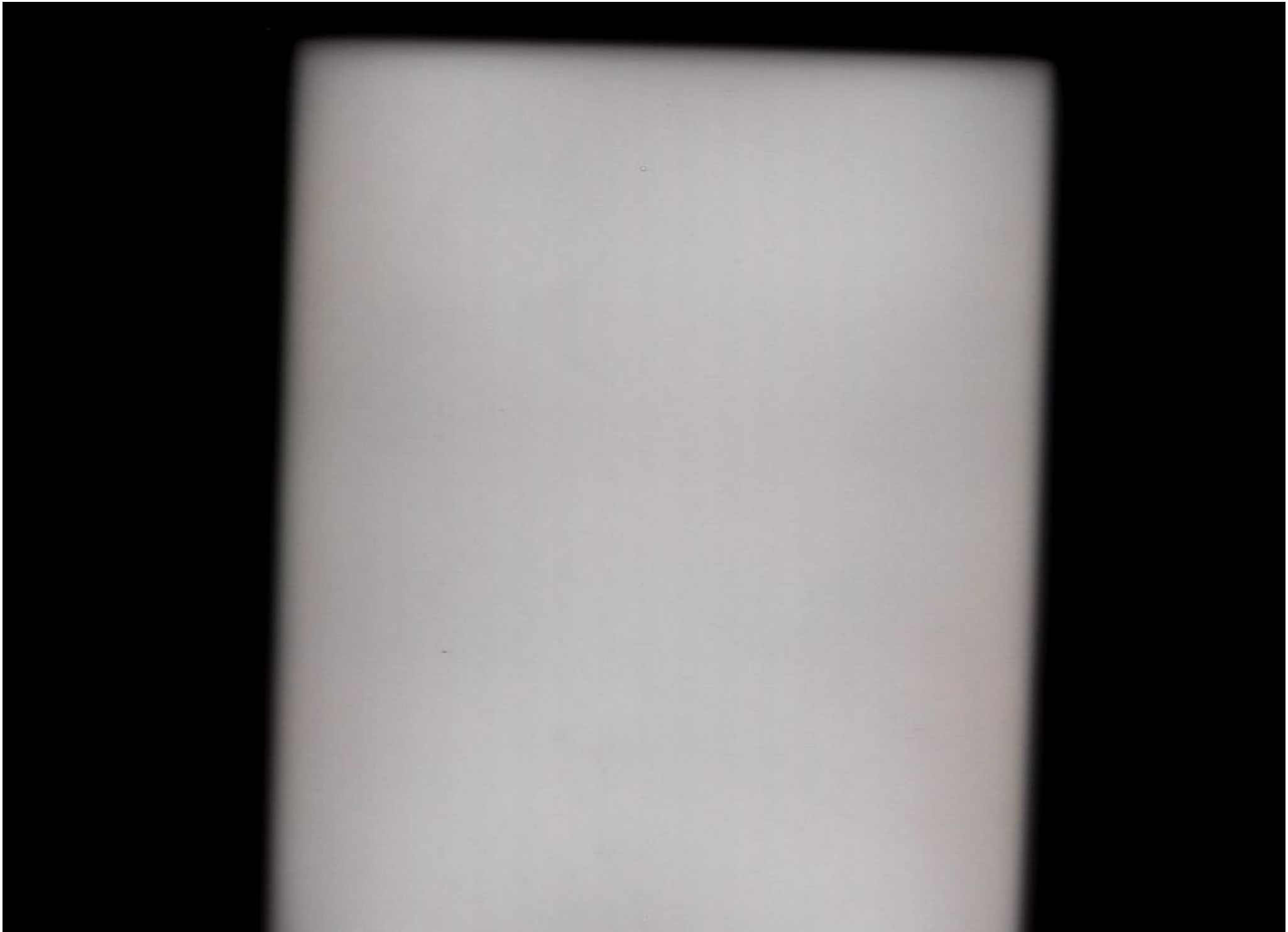

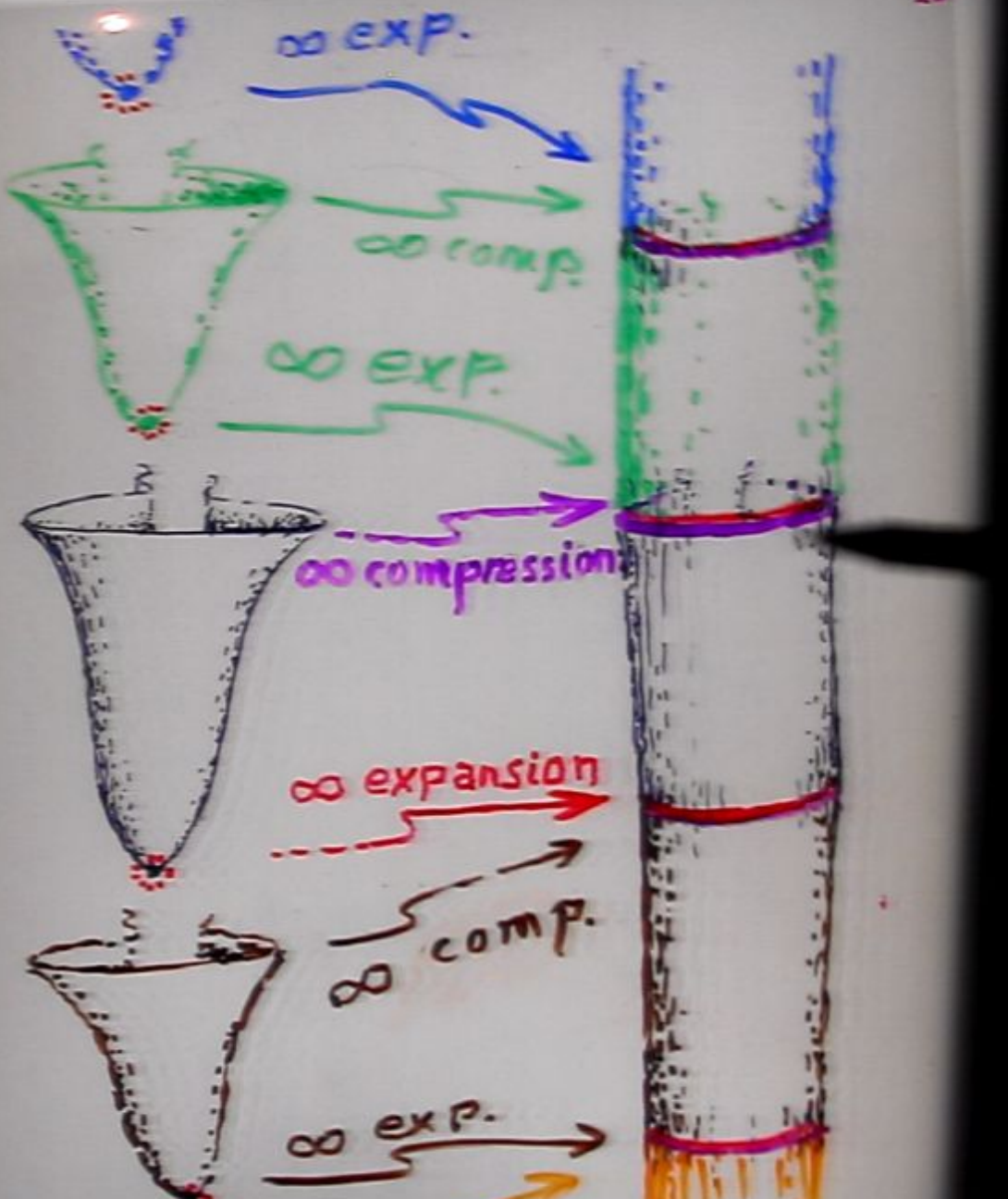
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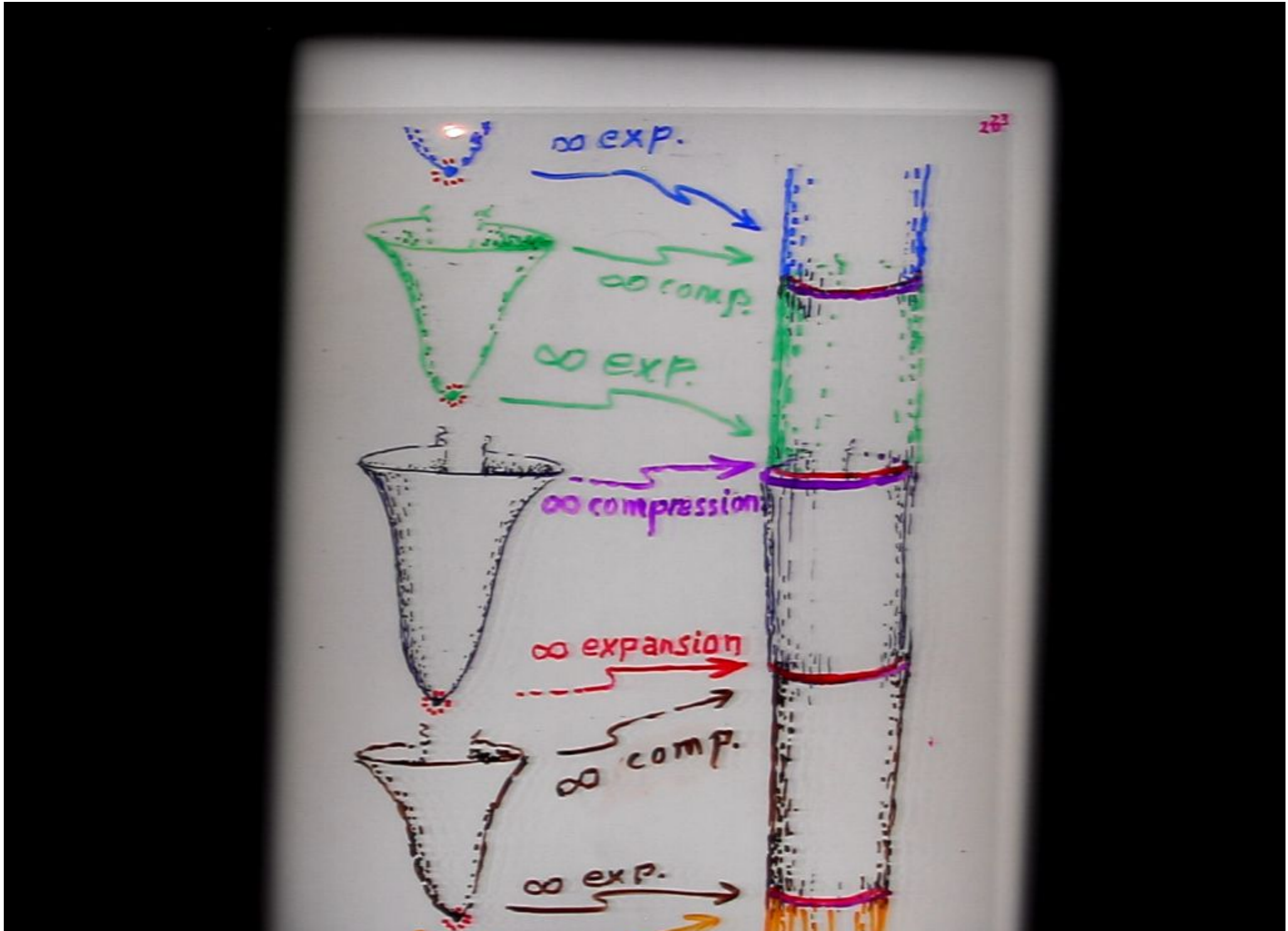
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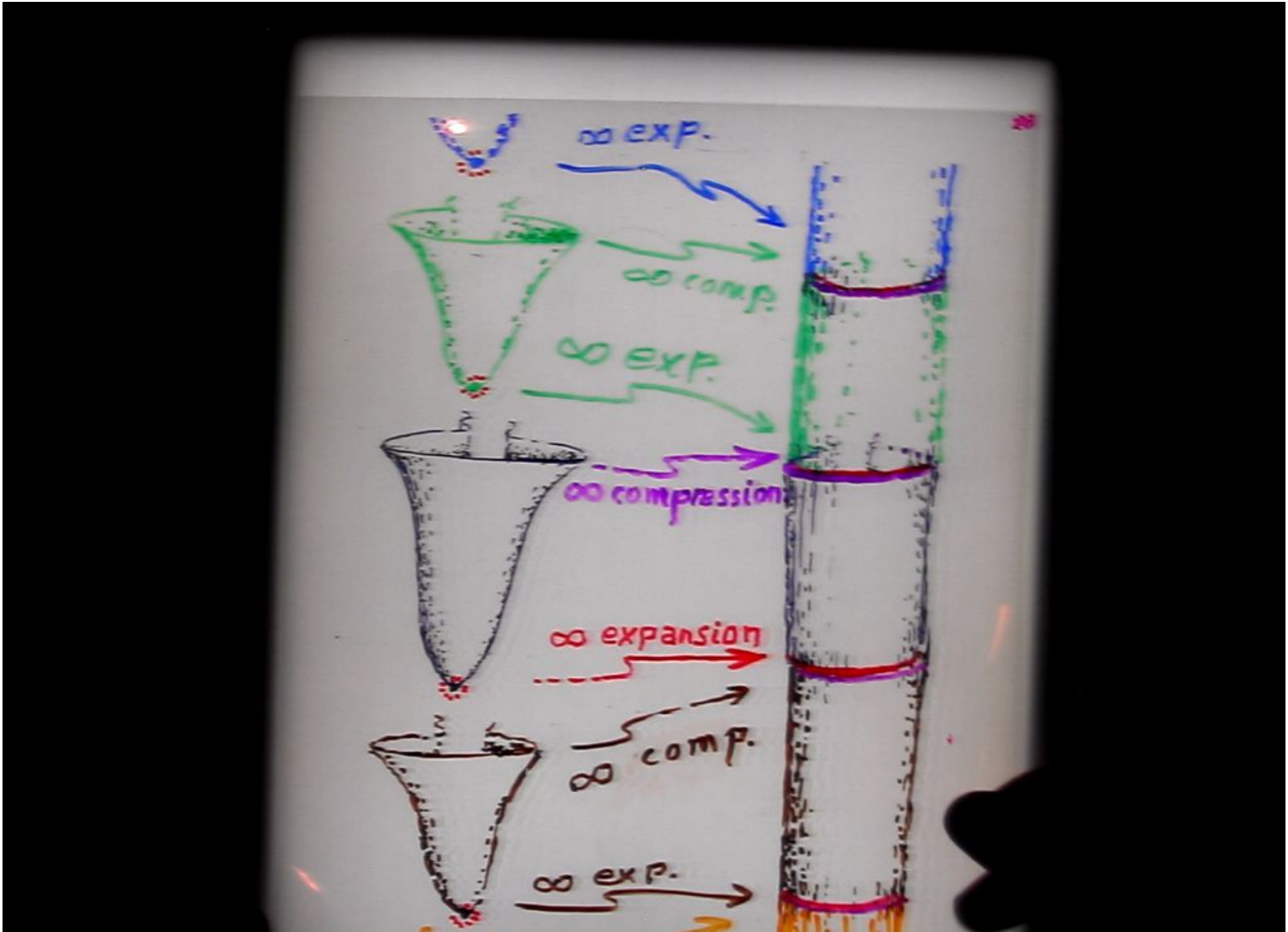
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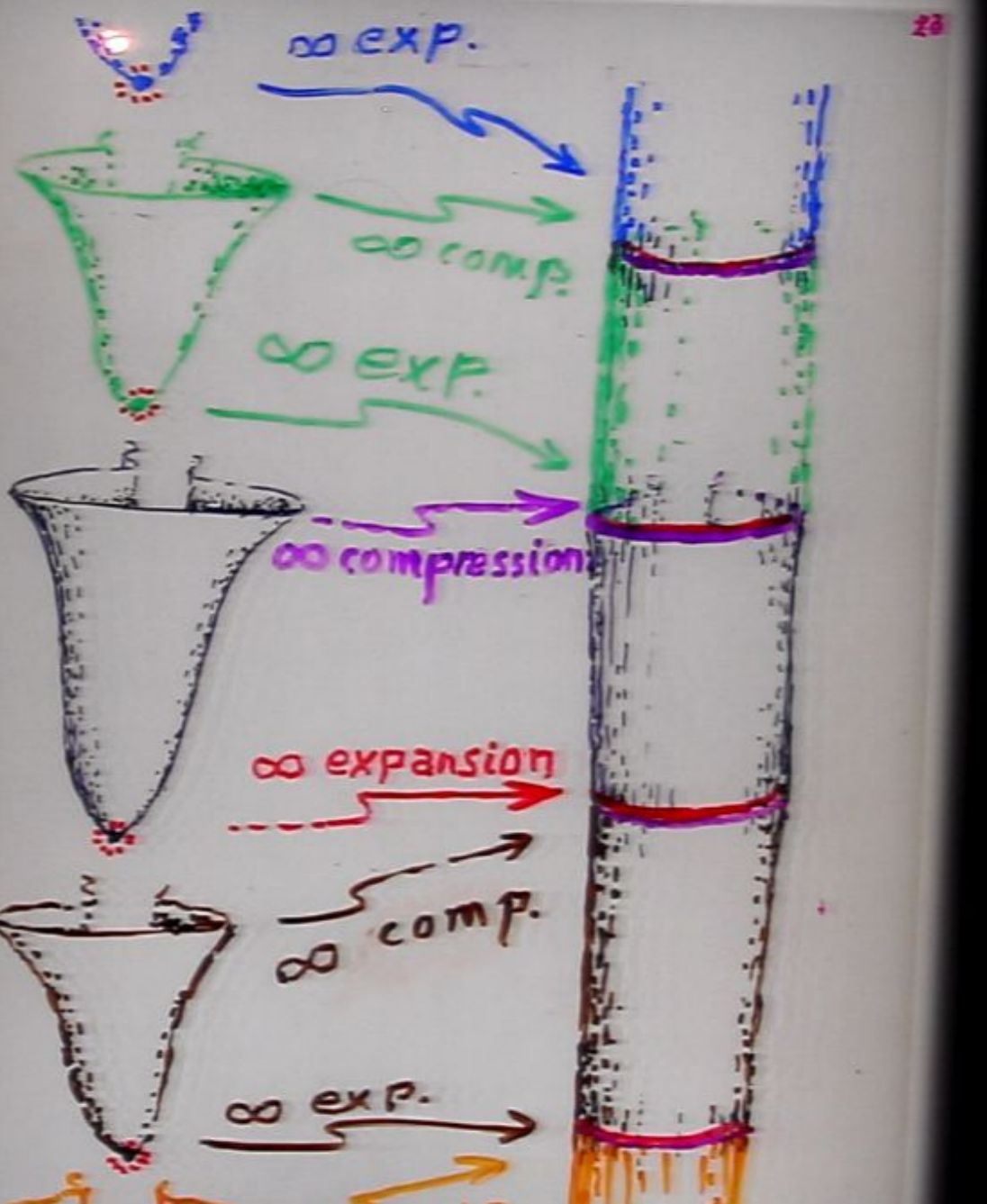
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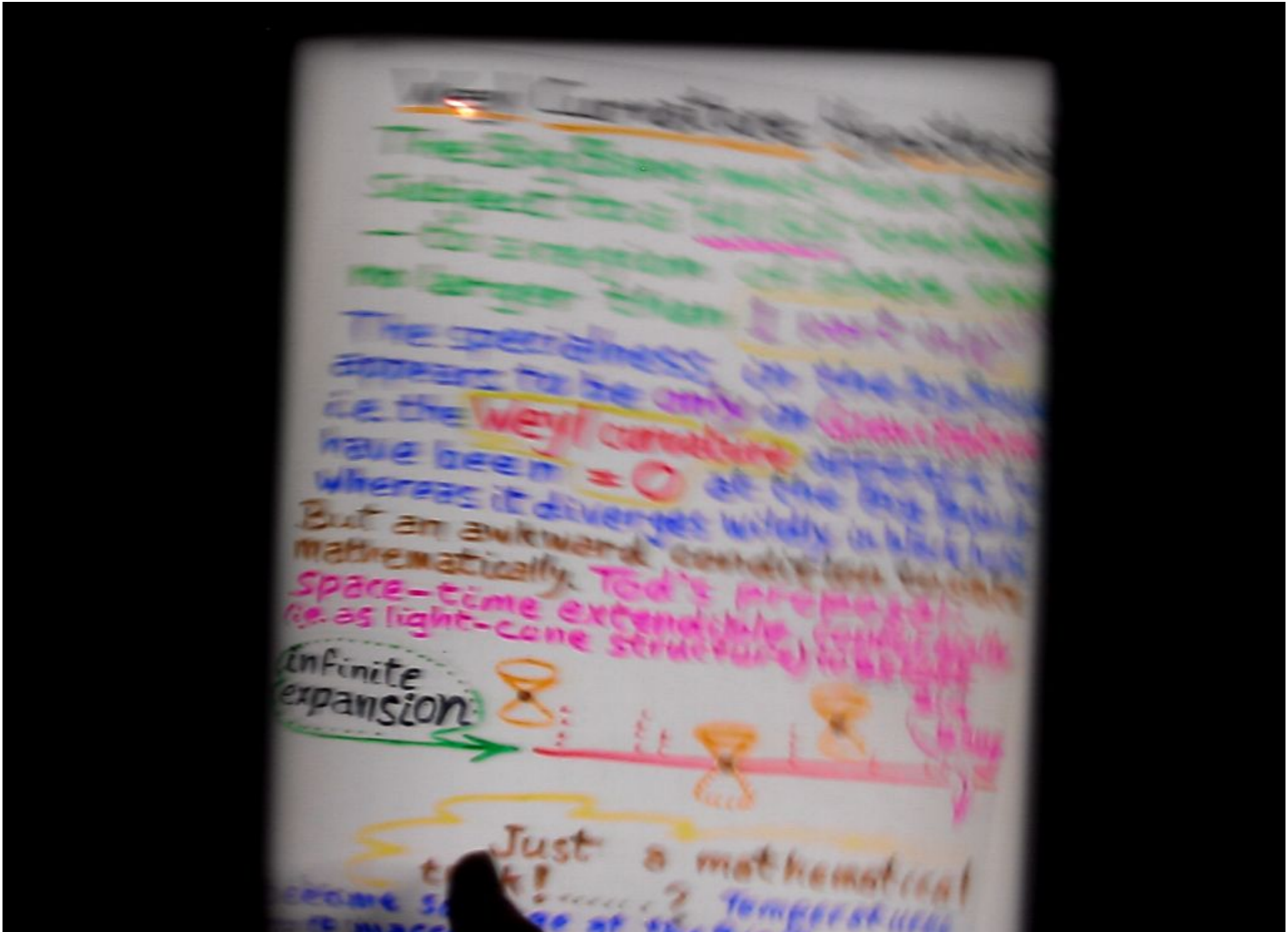
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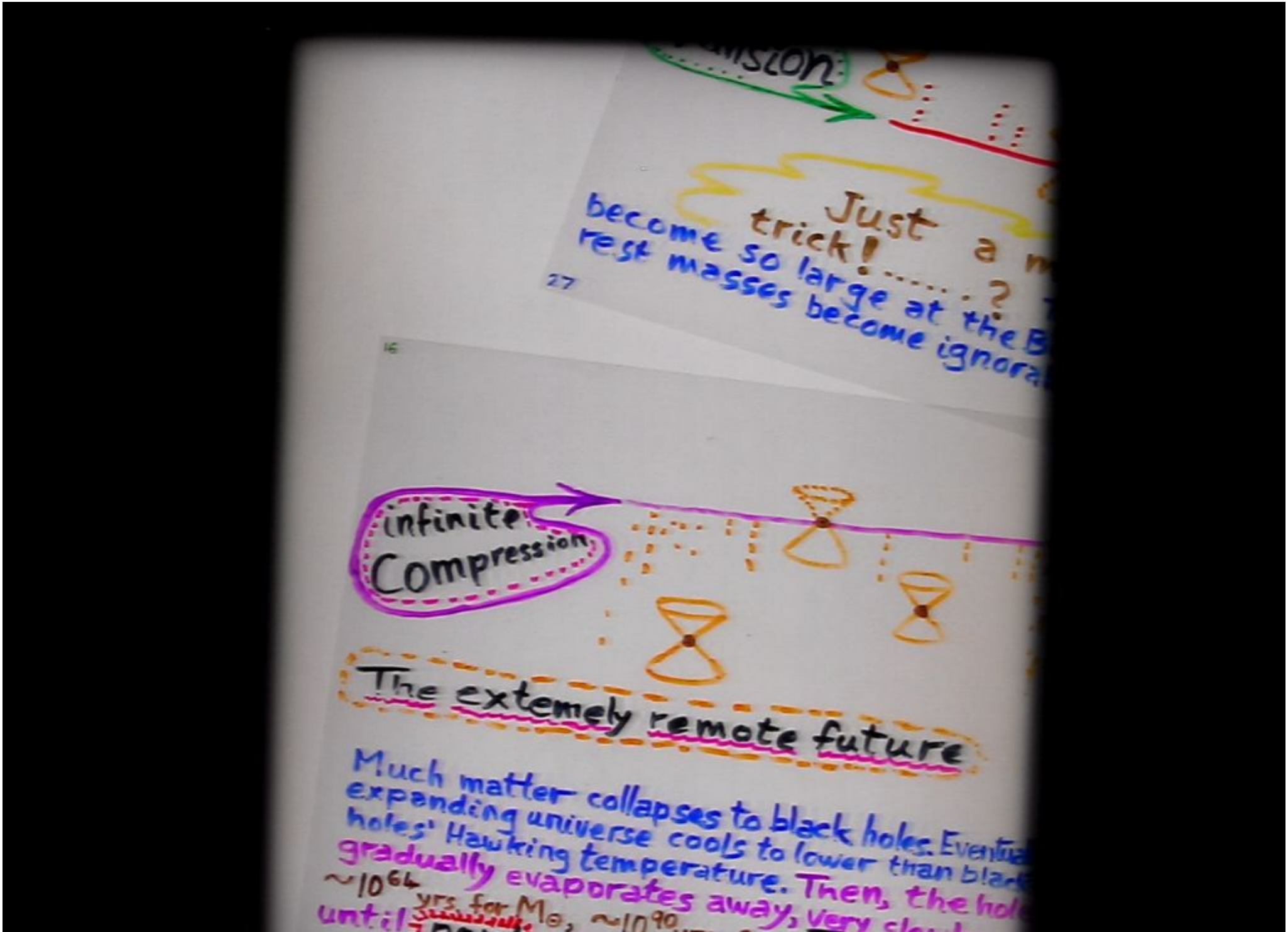
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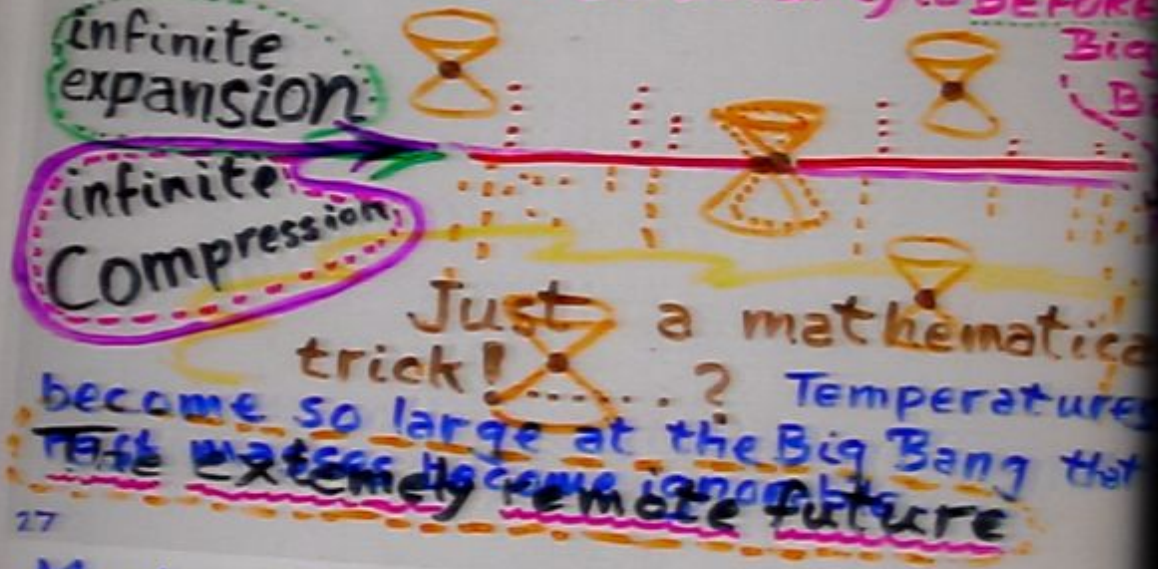

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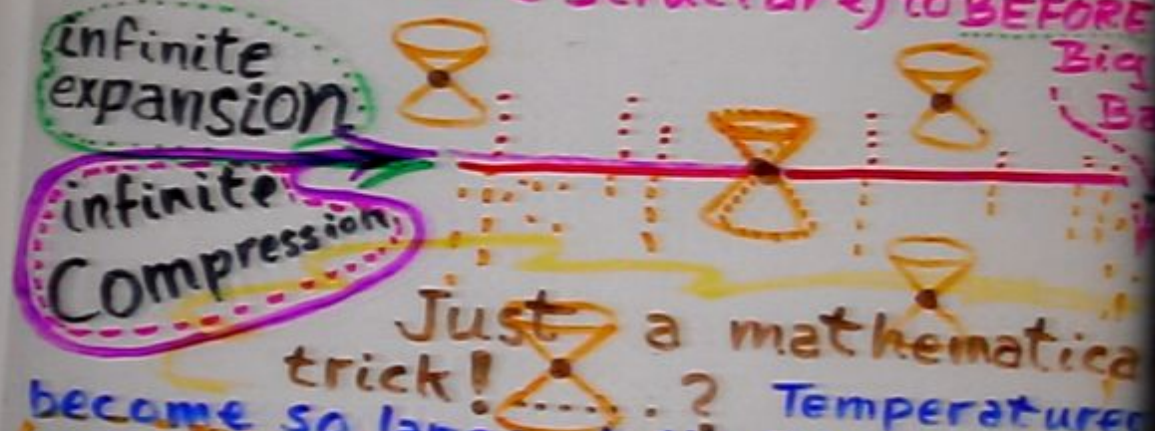

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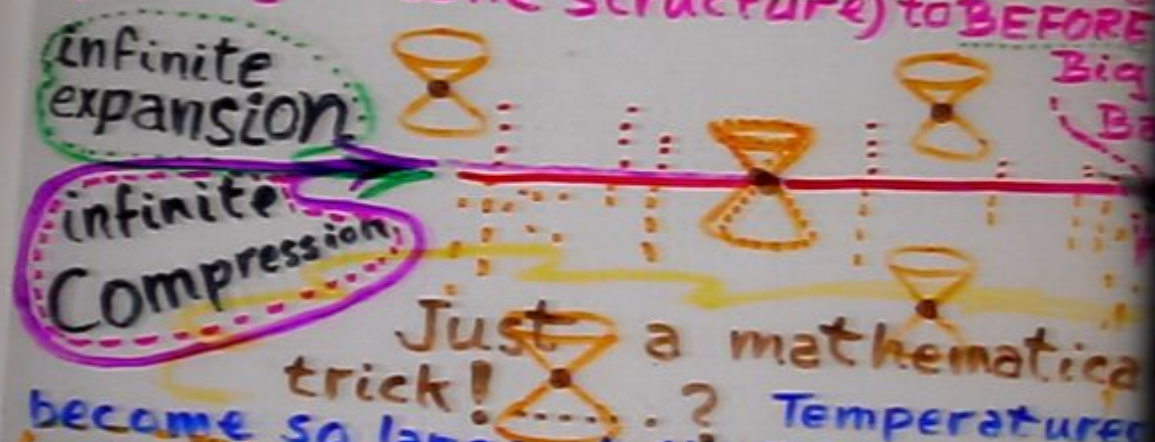

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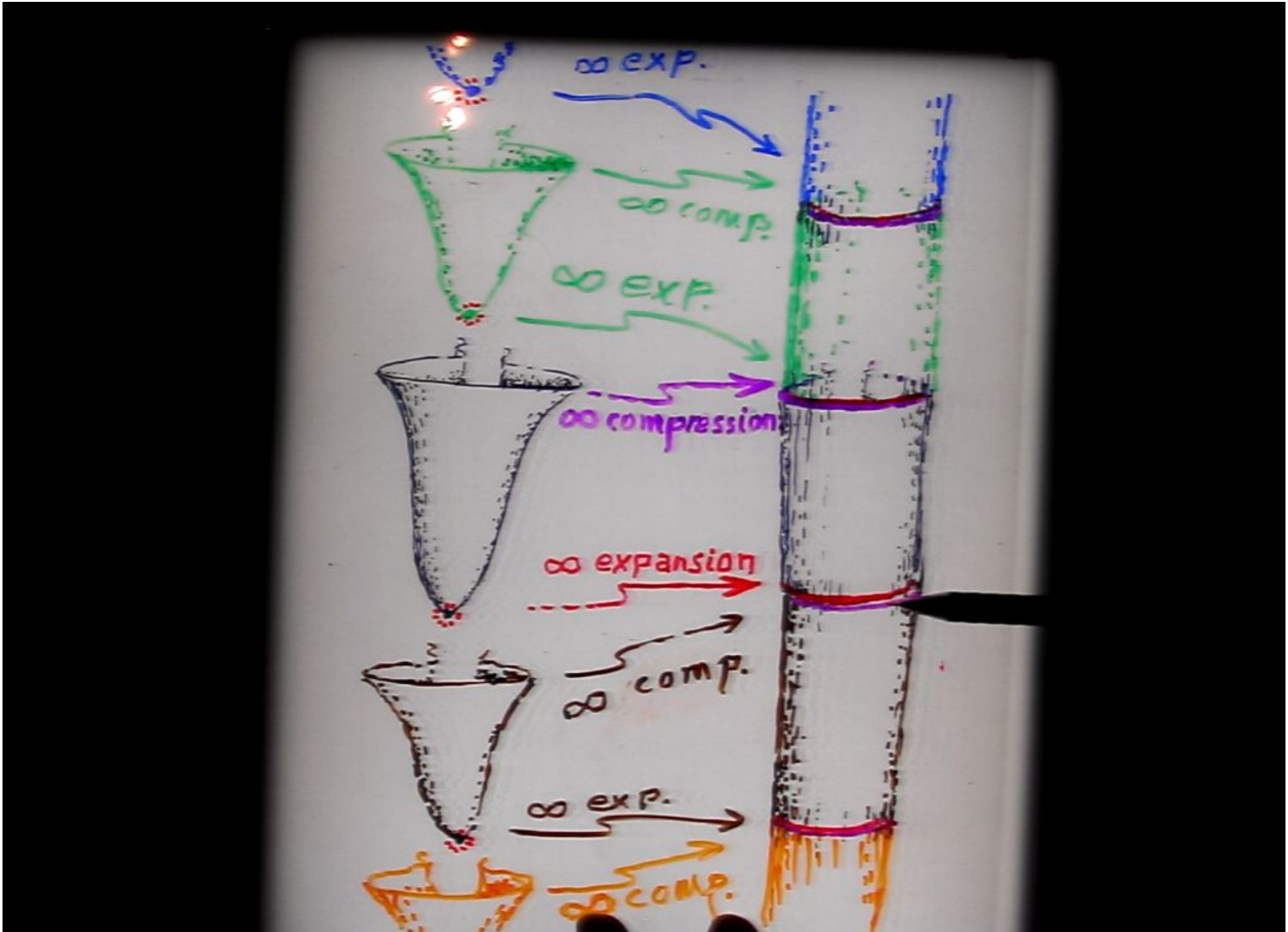
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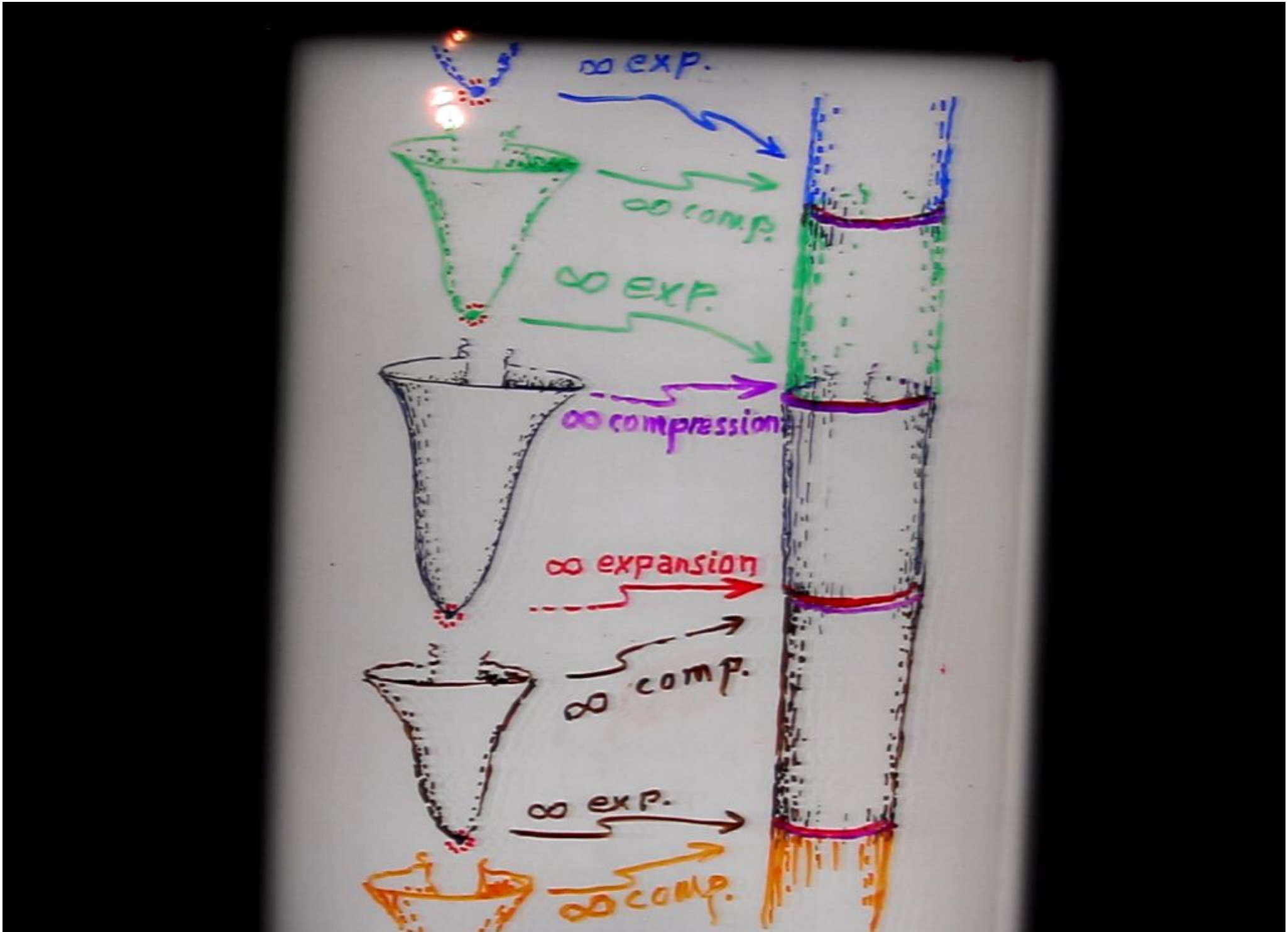
∞ exp.
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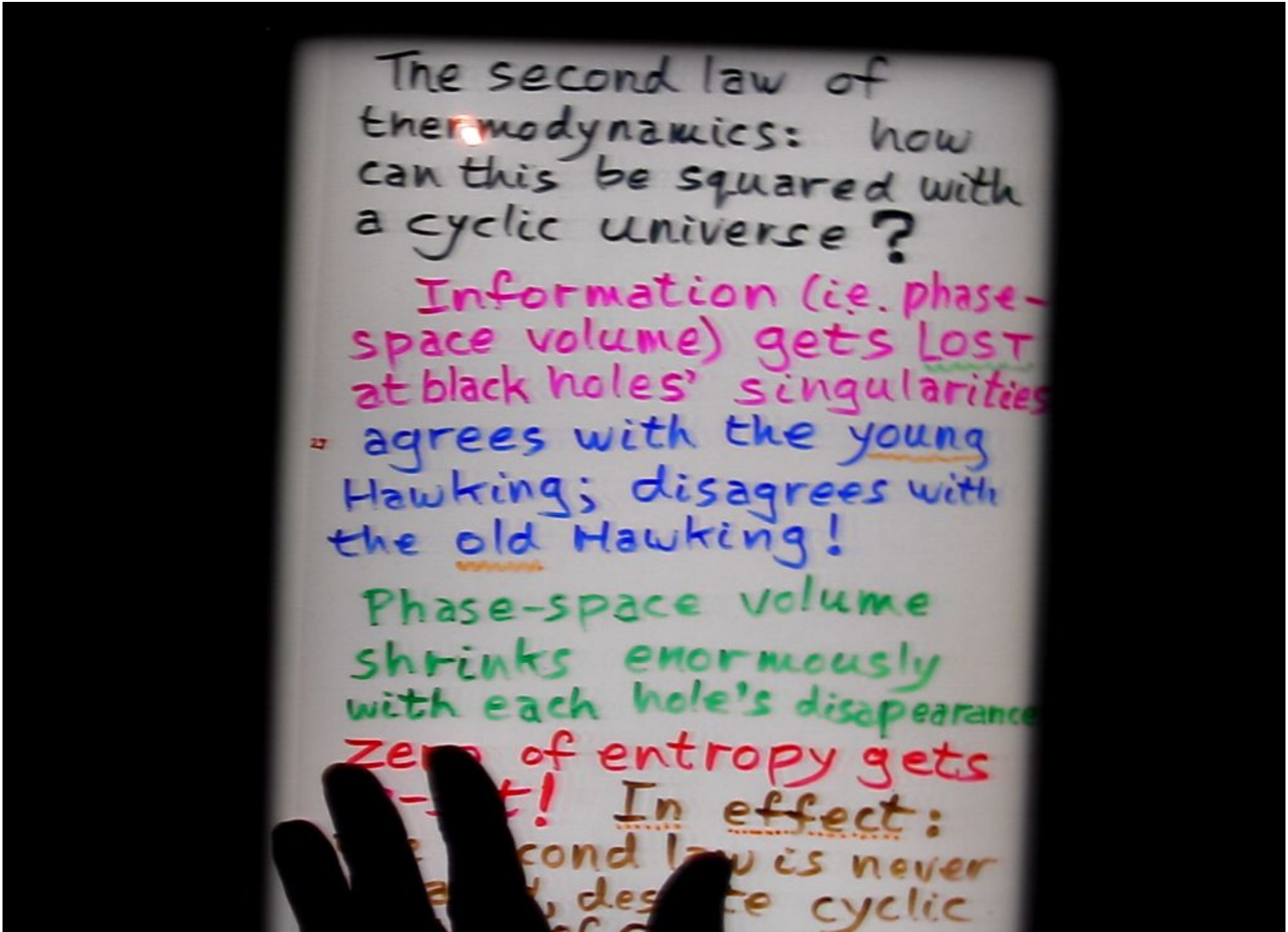

The second law of thermodynamics: how can this be squared with a cyclic universe?

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 with each hole's disapearance

Zero of entropy gets [illegible]t! In effect:

[illegible]cond law is never [illegible], des[illegible]te cyclic

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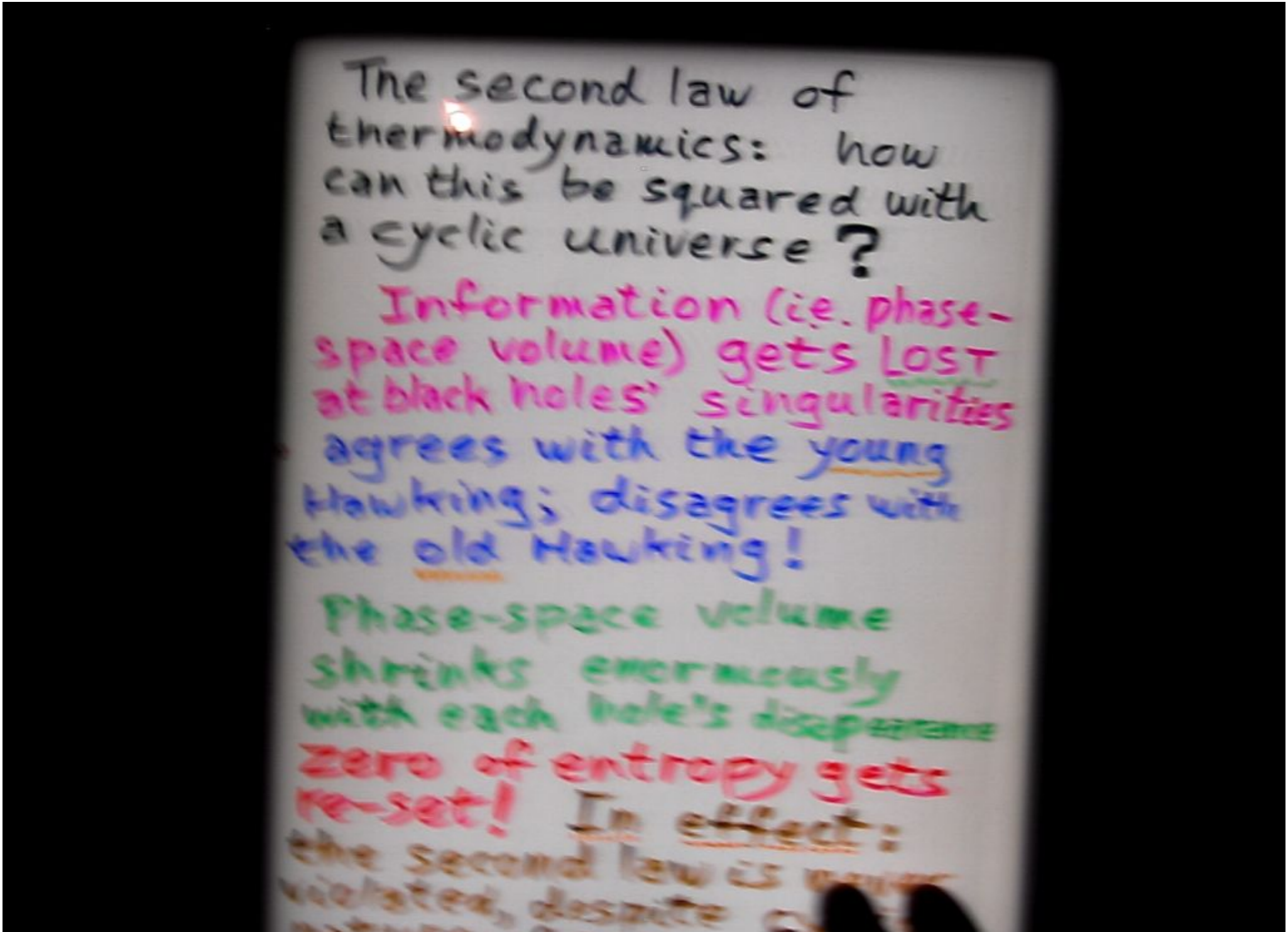
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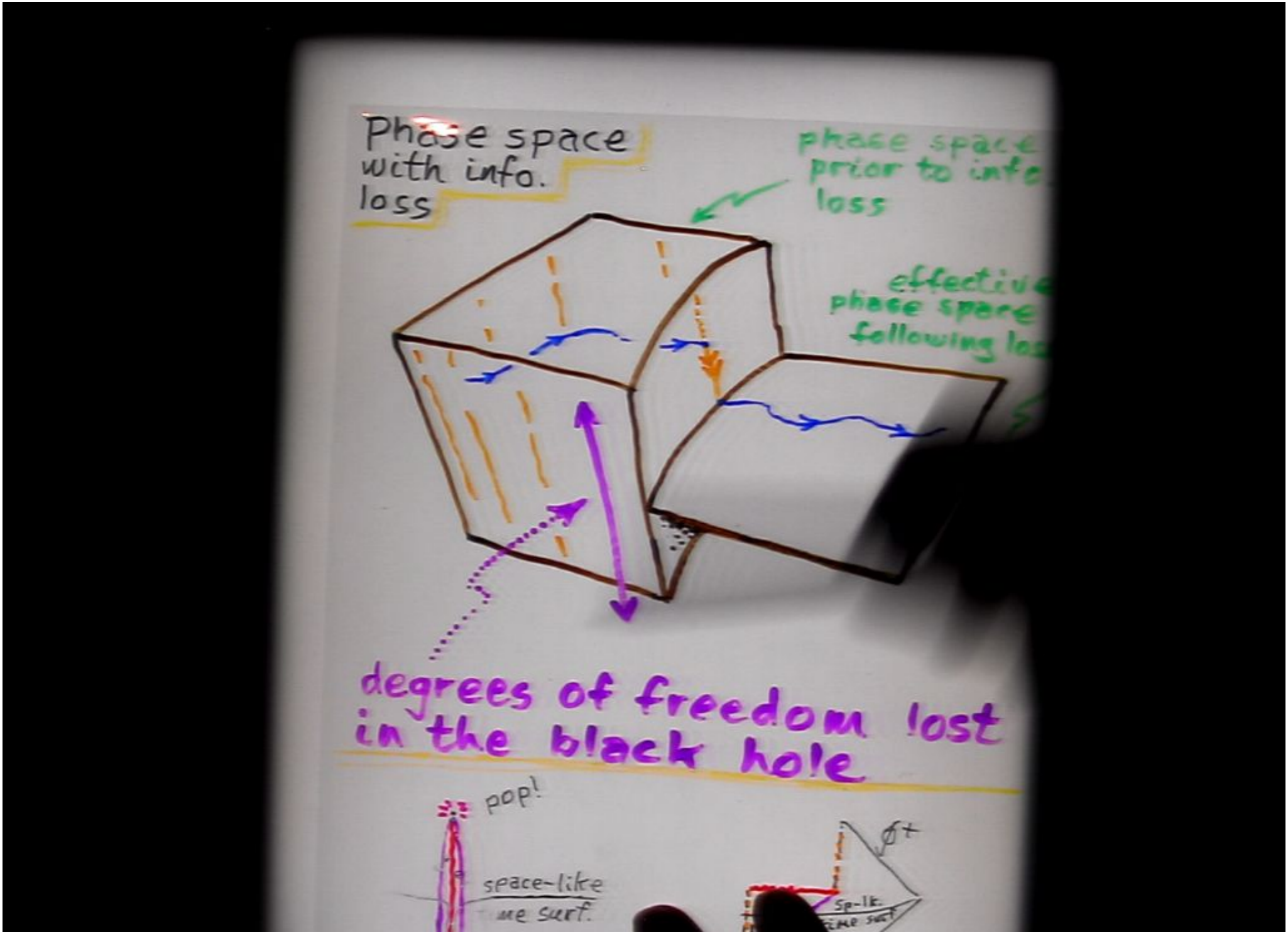
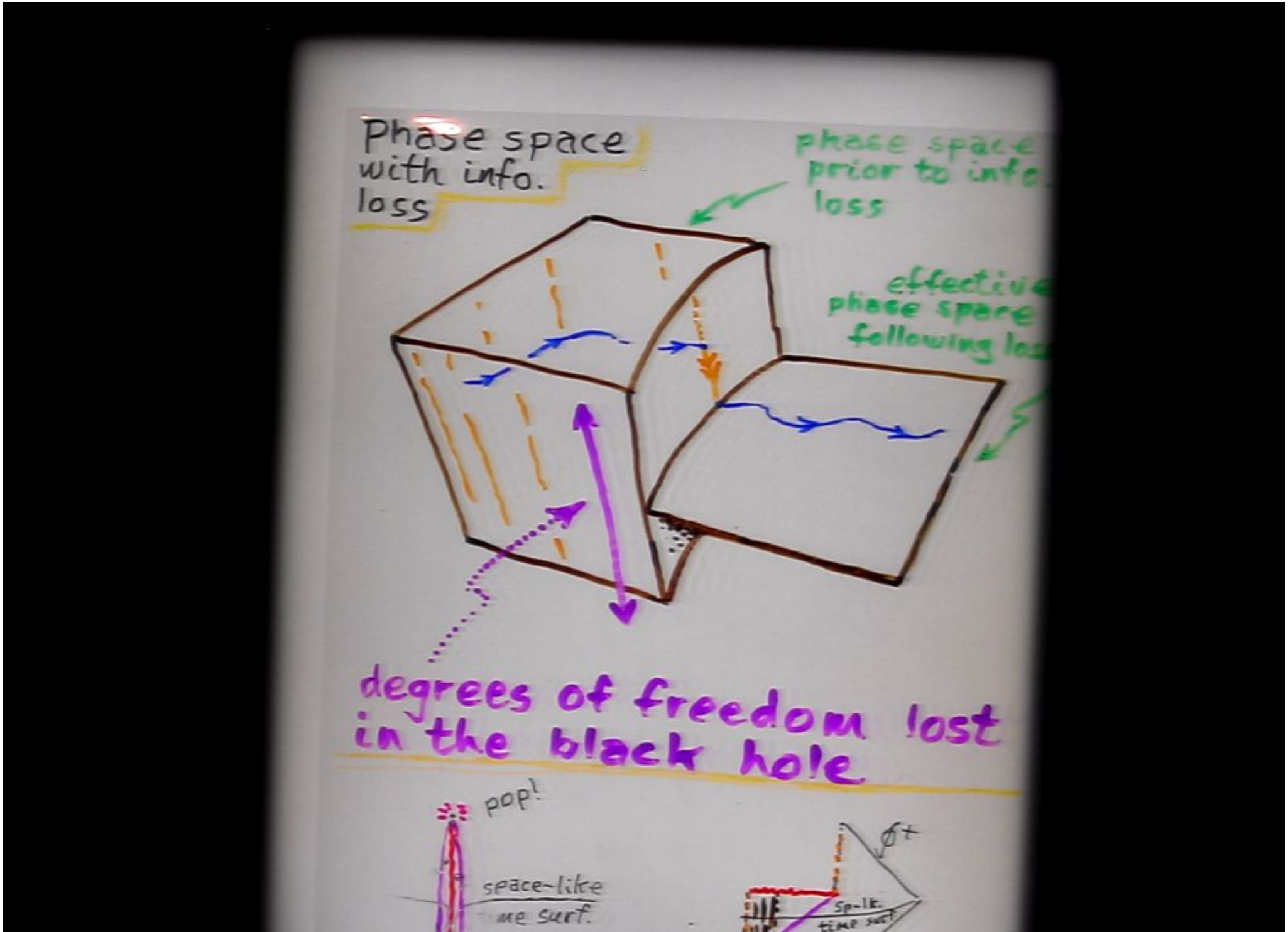

Phase space with info. loss
phase space prior to info. loss
effective phase space following loss
degrees of freedom lost in the black hole
pop!
space-like
me surf.
Sp-lk.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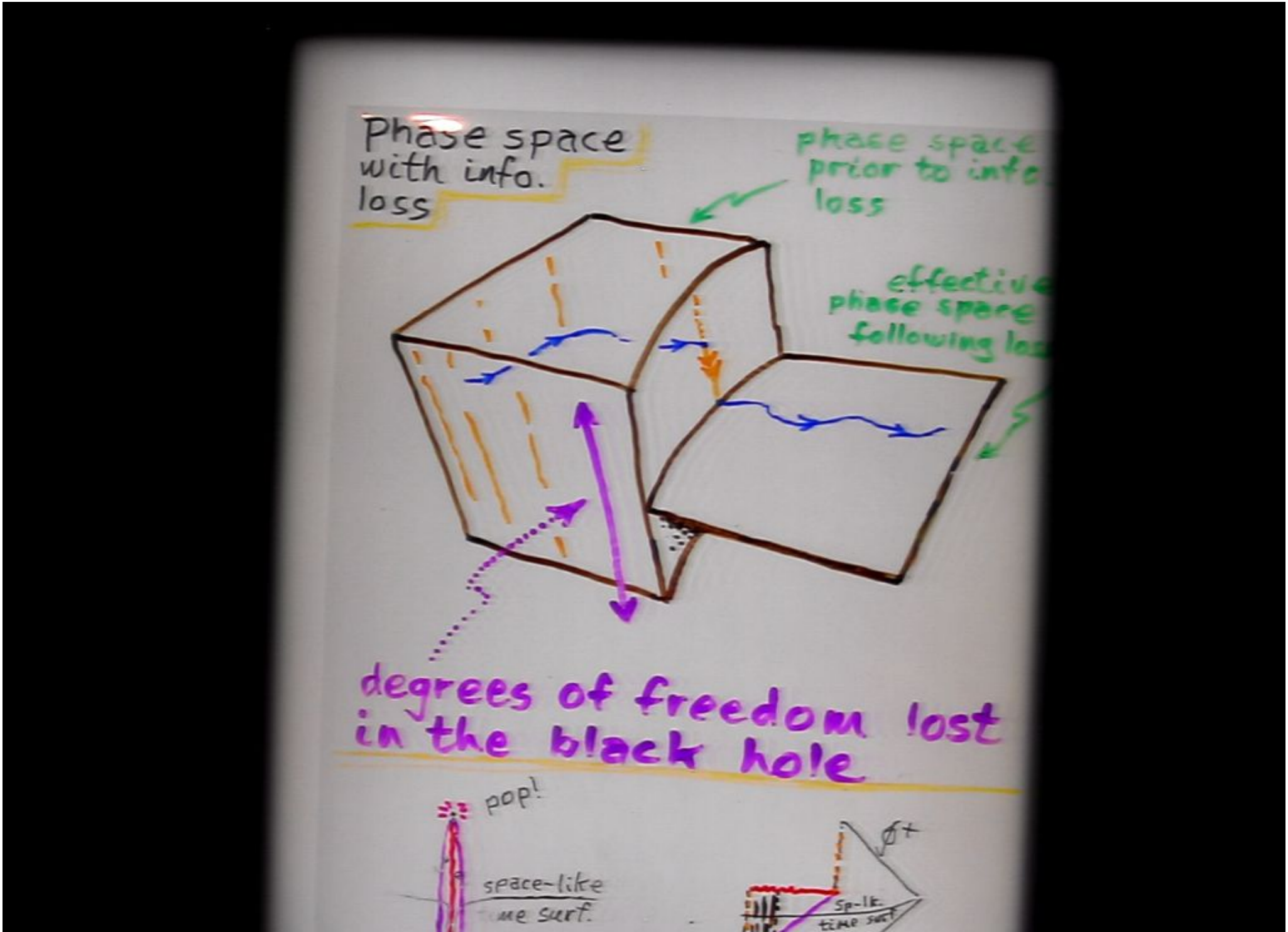
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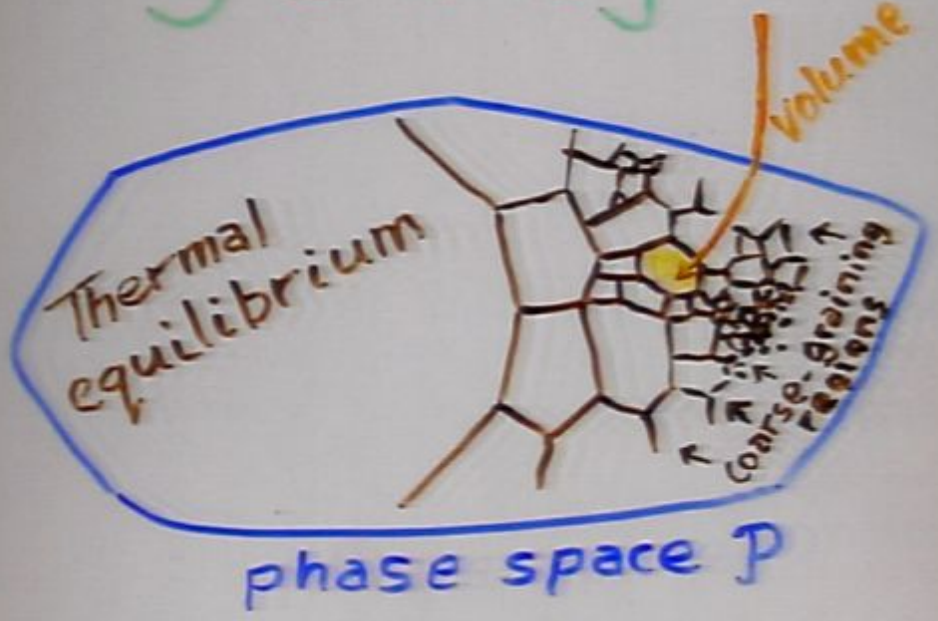
Boltzmann's definition of ENTROPY

$$S = k \log V$$



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

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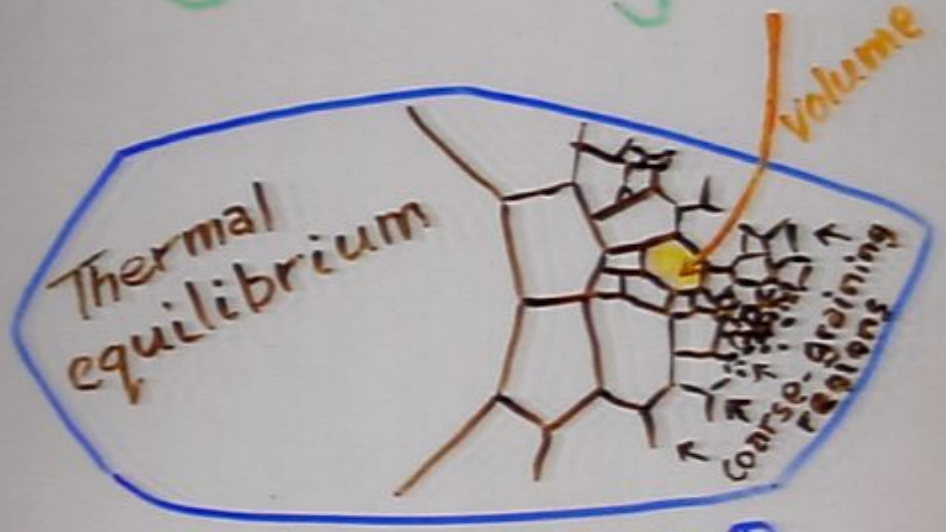

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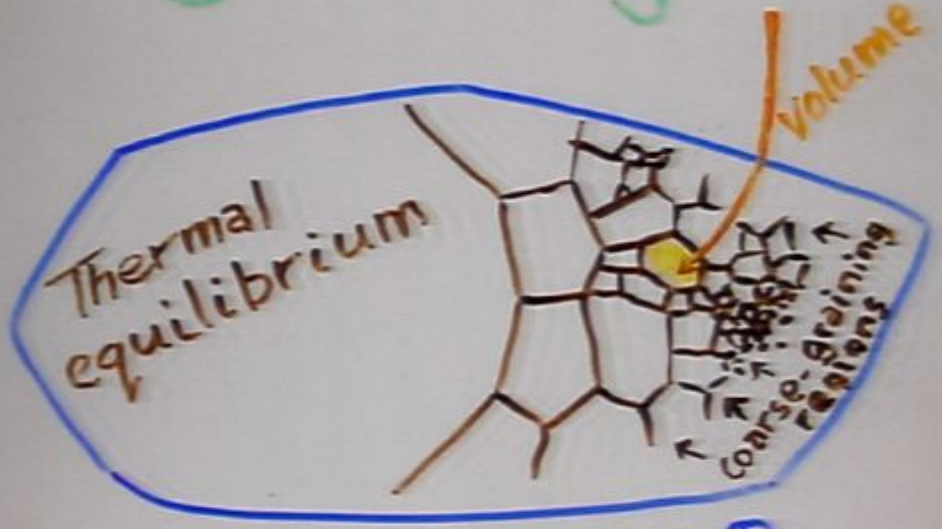

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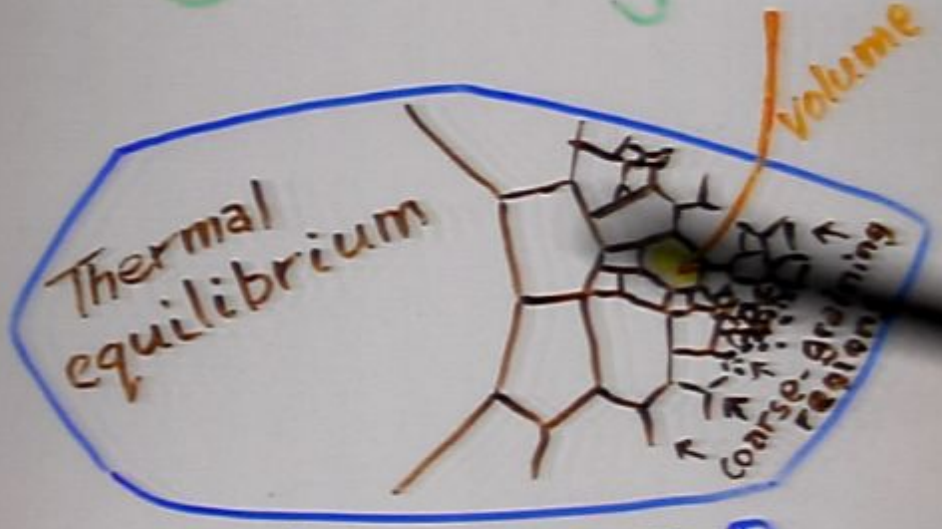

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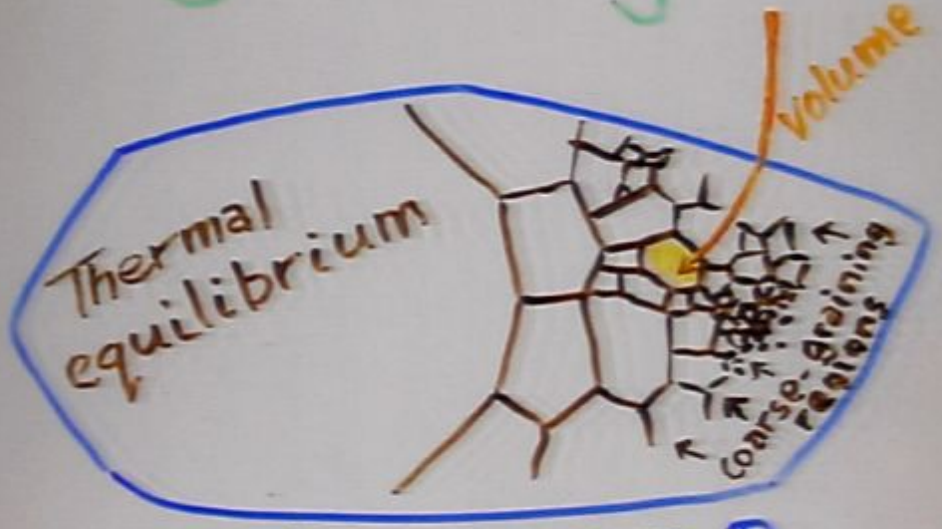

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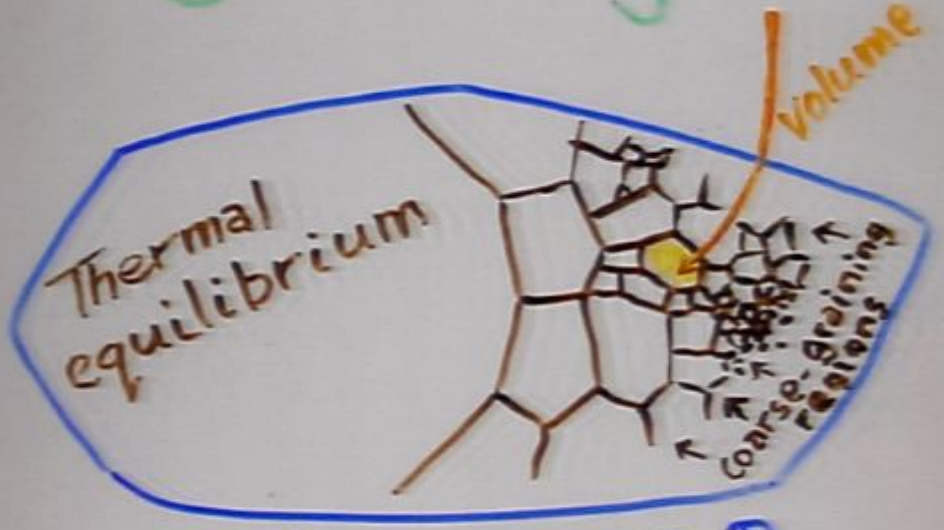

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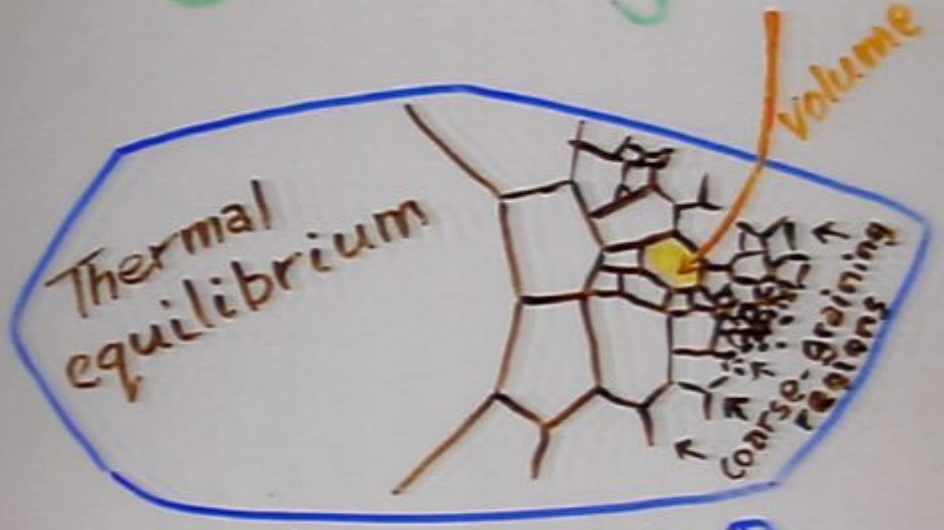

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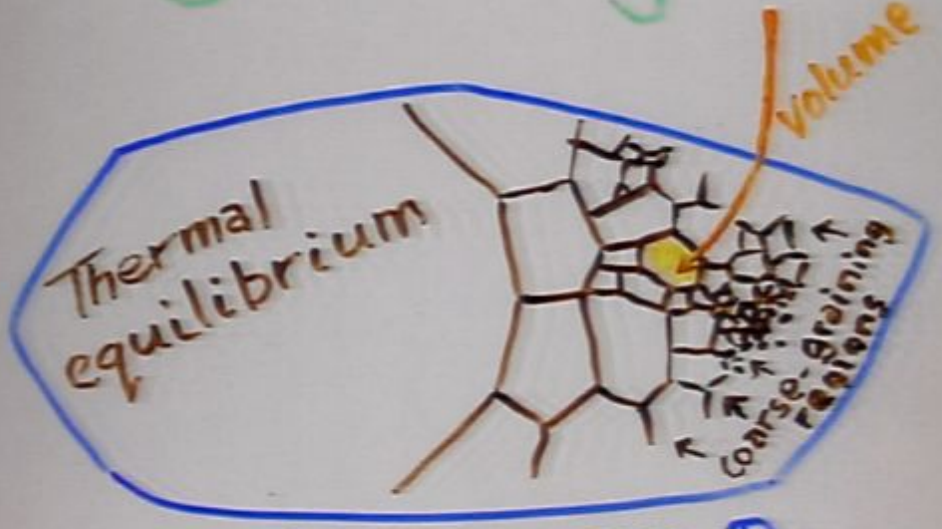

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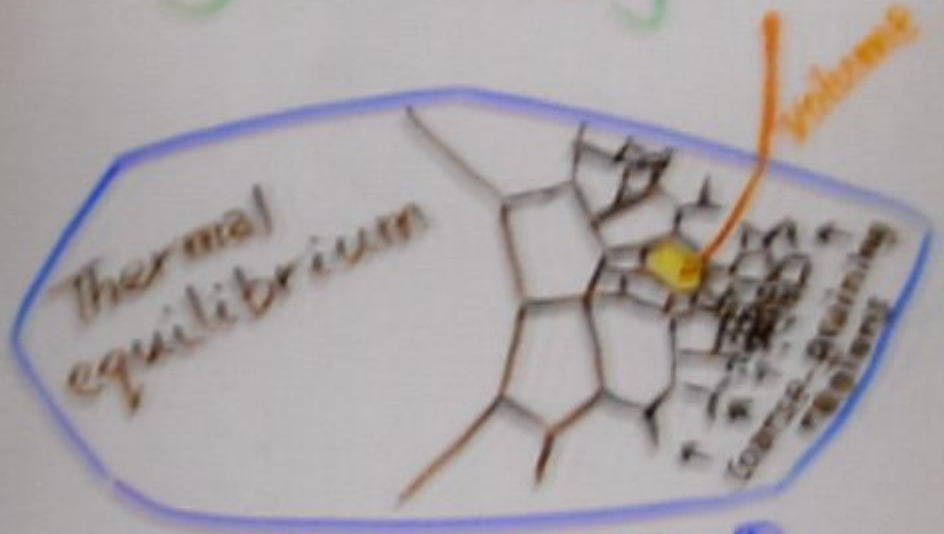

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So entropy is additive for independent systems

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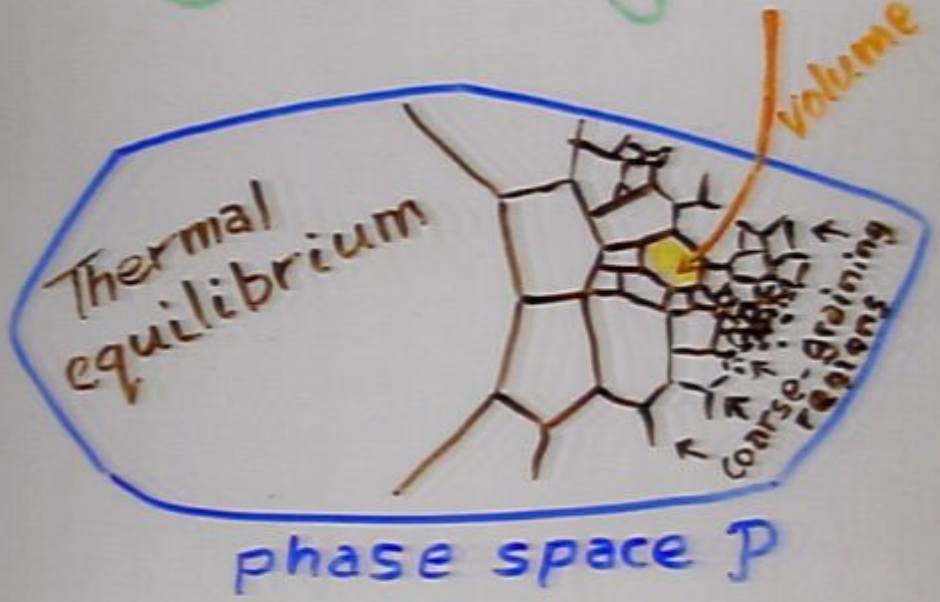

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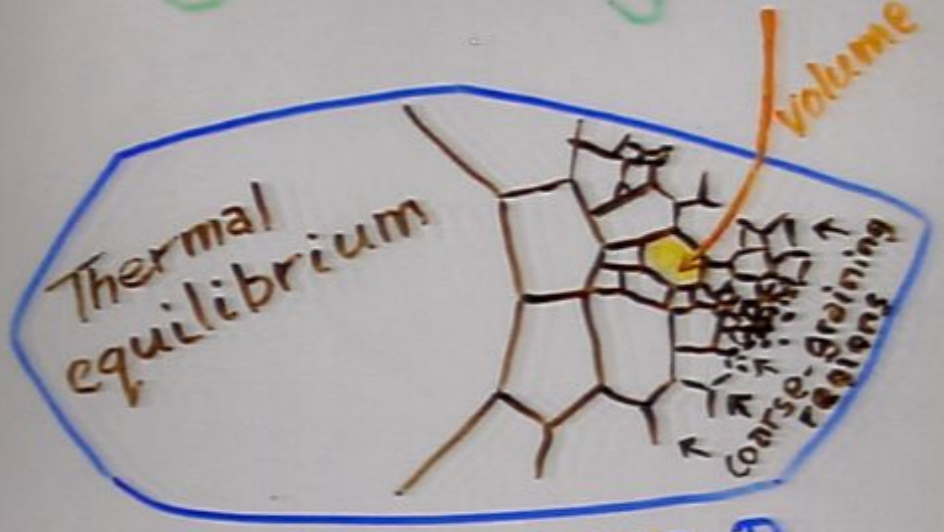

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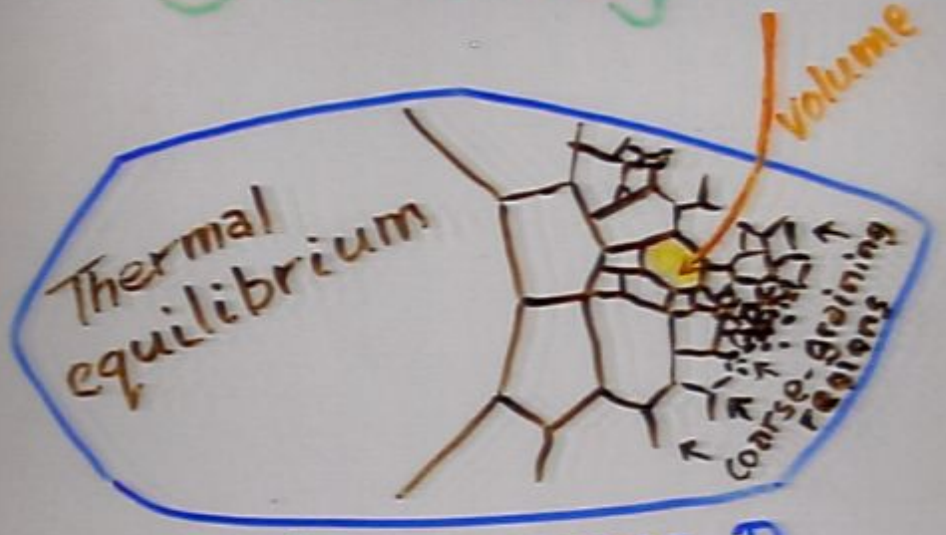

phase space $\mathcal{P}$

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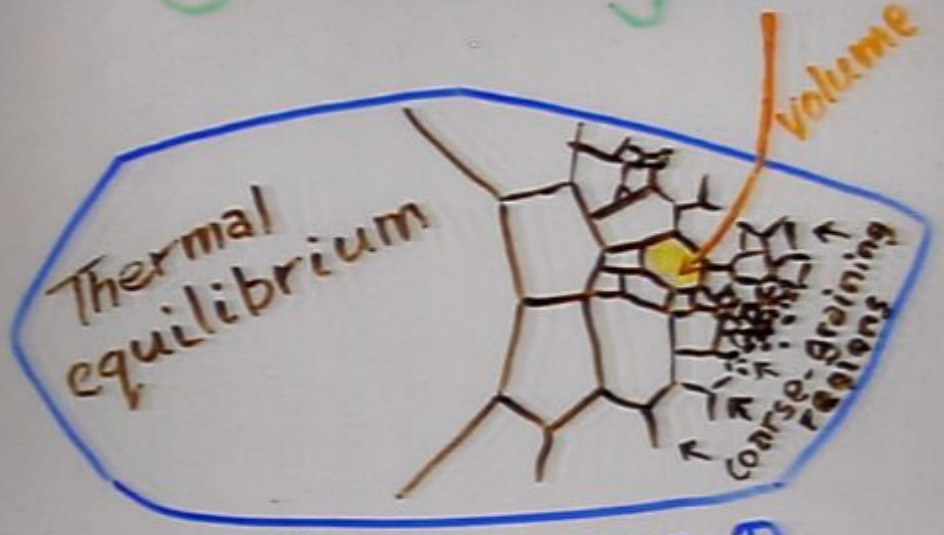

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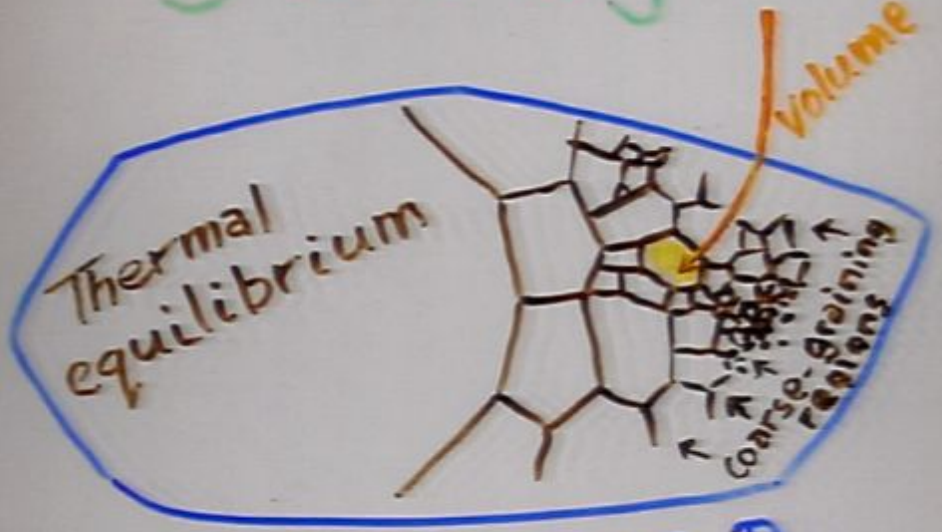

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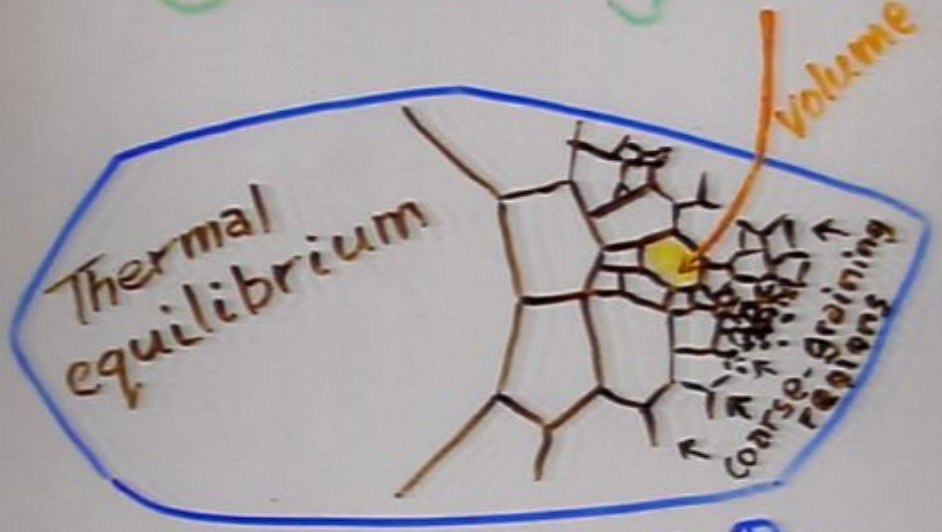

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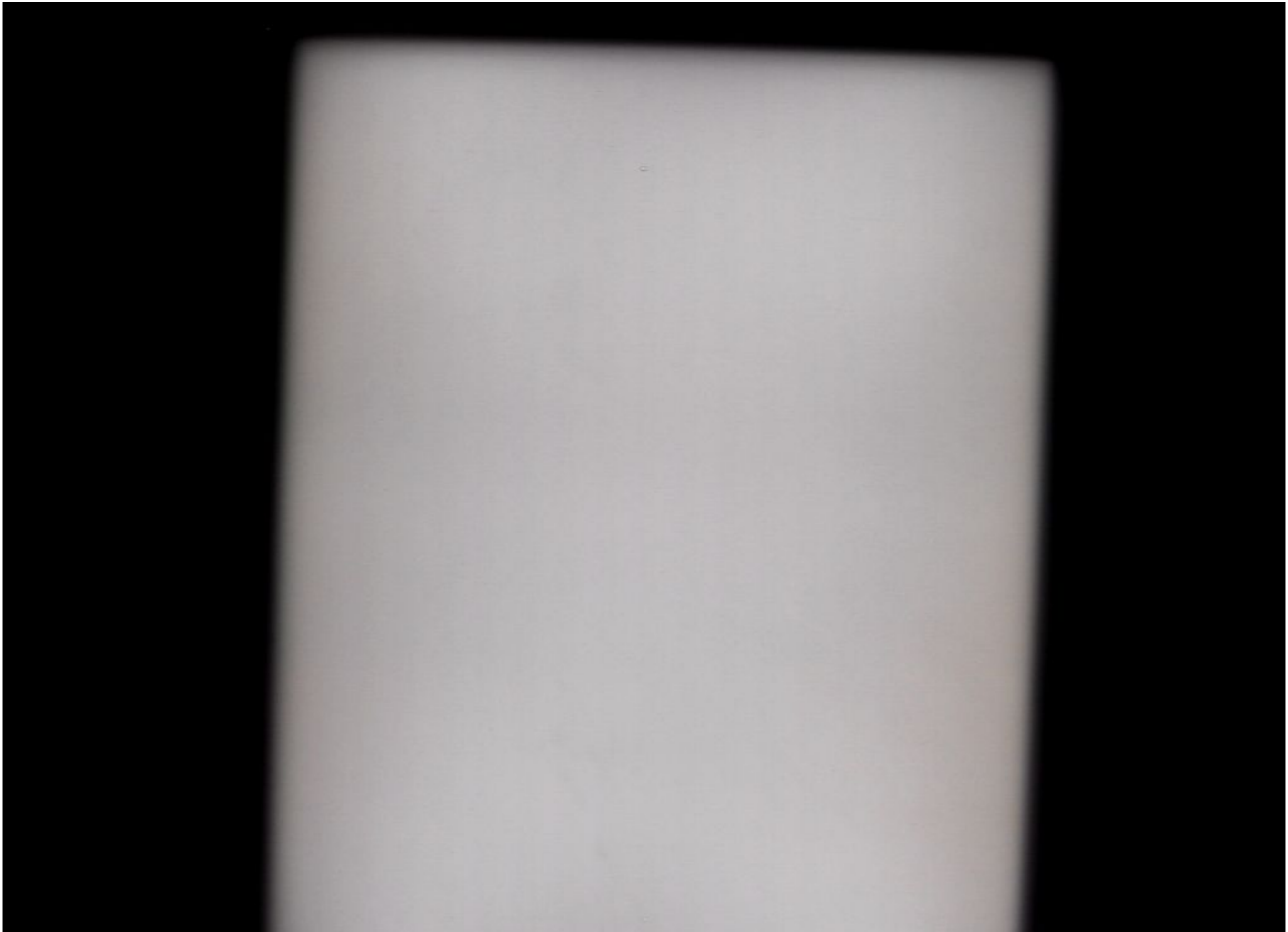
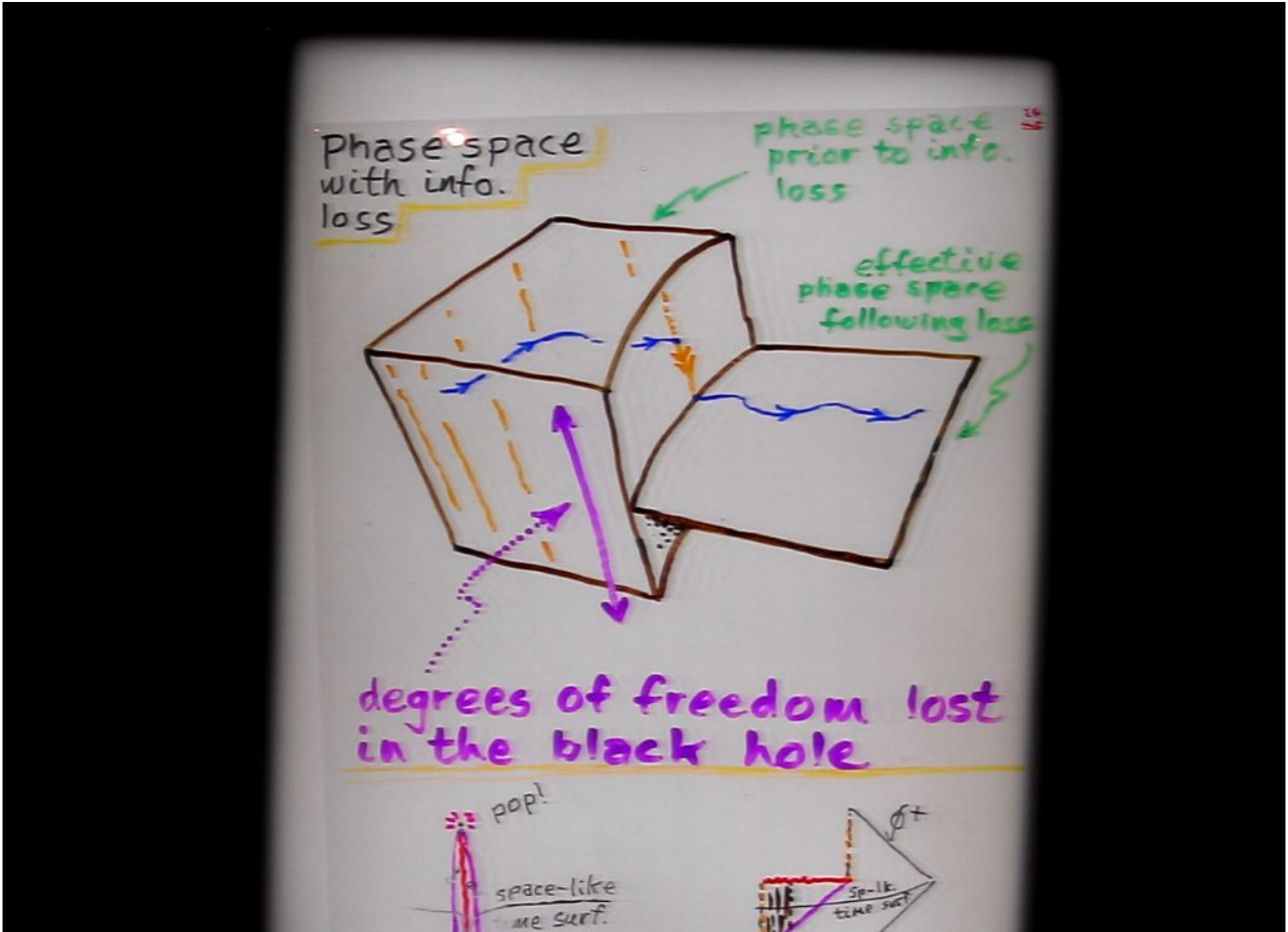
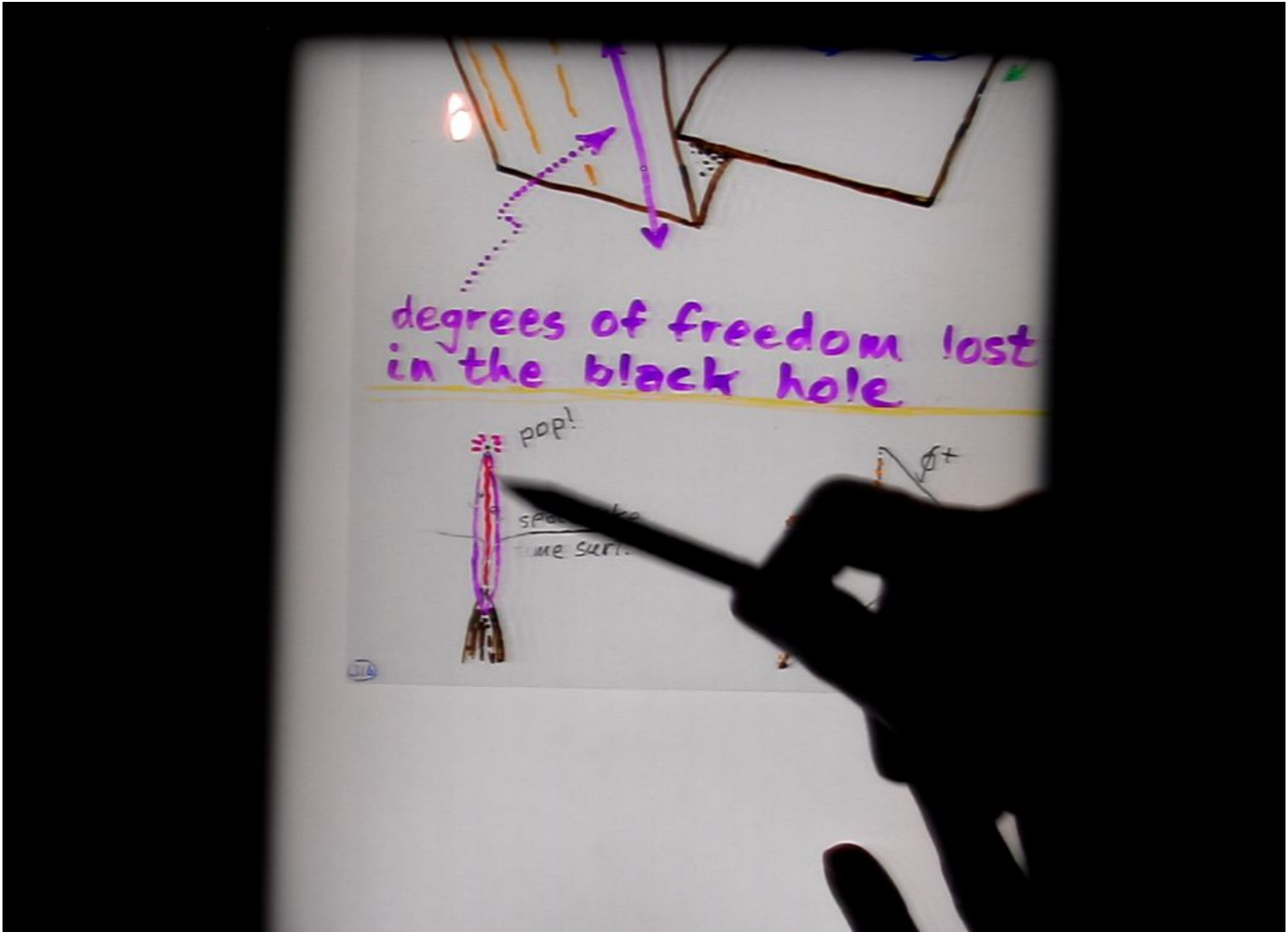



Phase space with info. loss
phase space prior to info. loss
effective phase space following loss
degrees of freedom lost in the black hole
pop!
space-like me surf.
Sp-lk. time surf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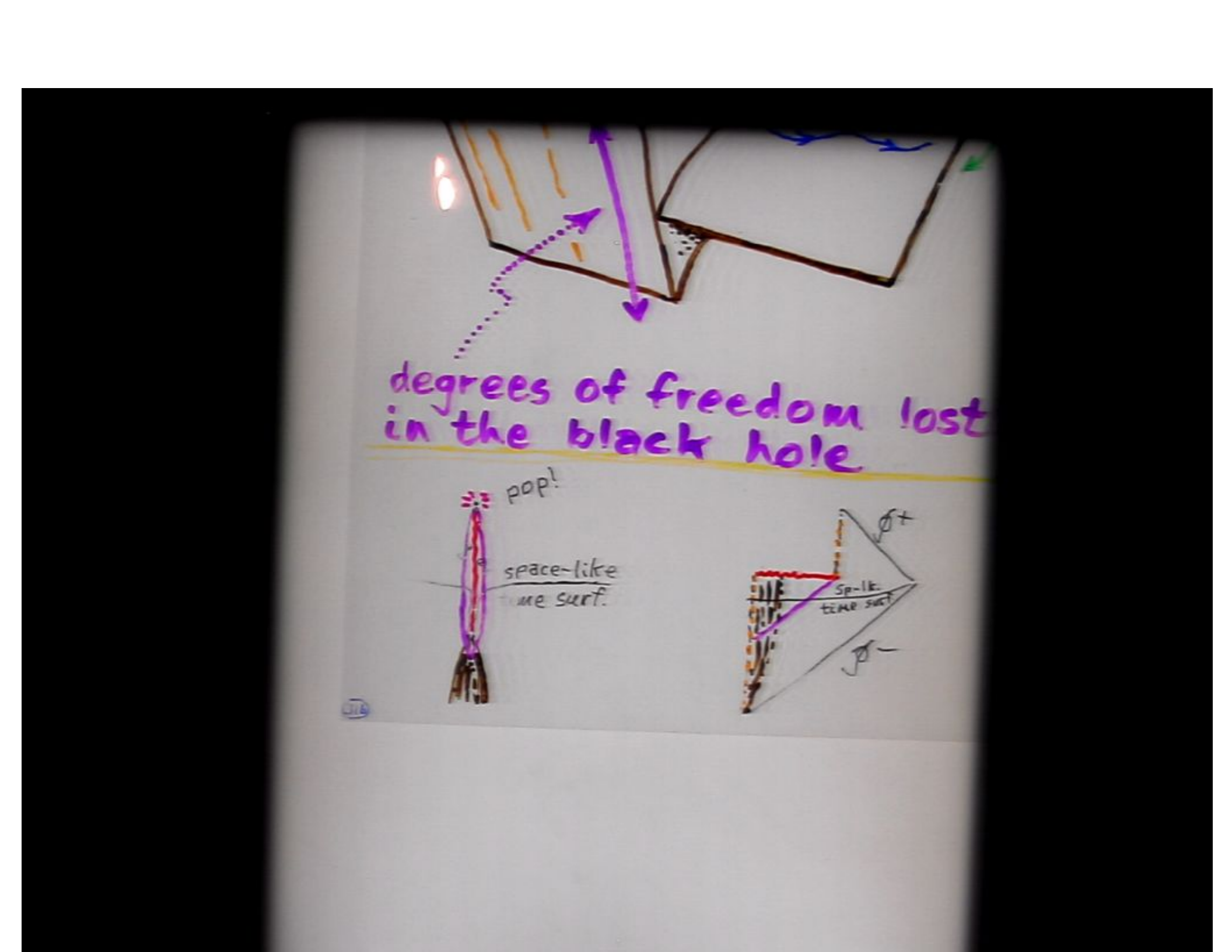
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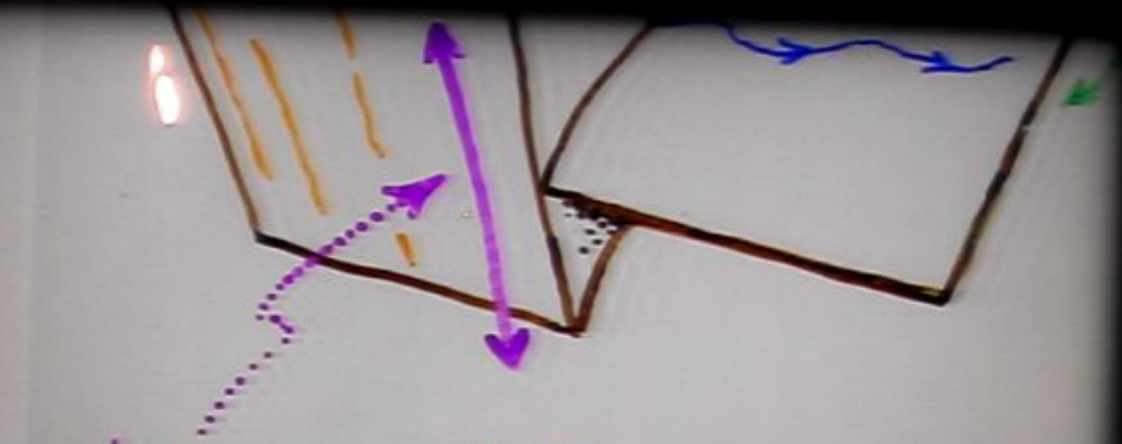

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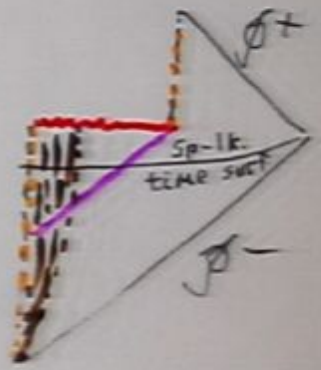

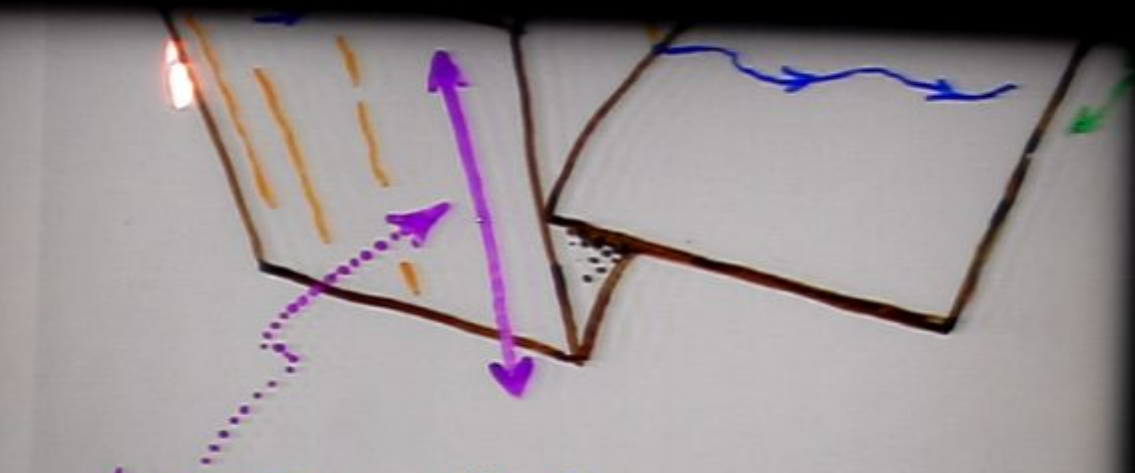

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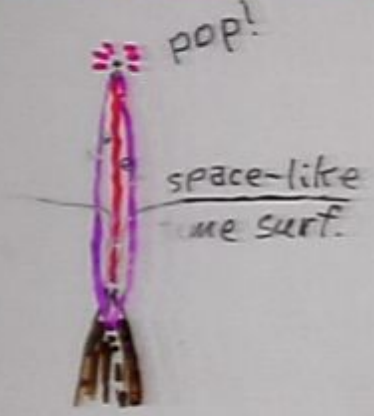

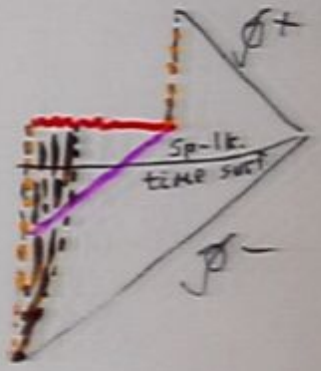

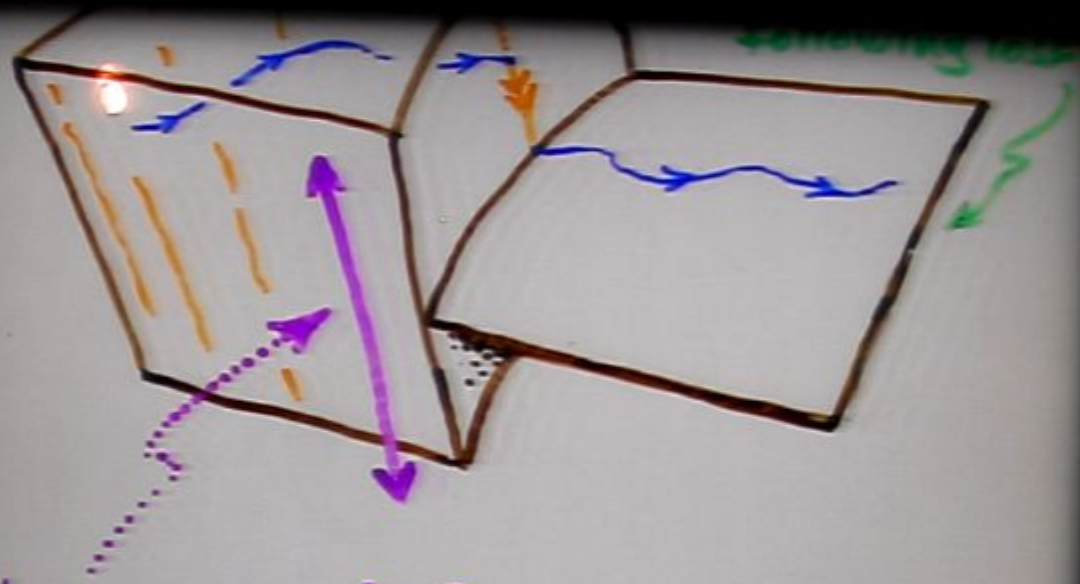

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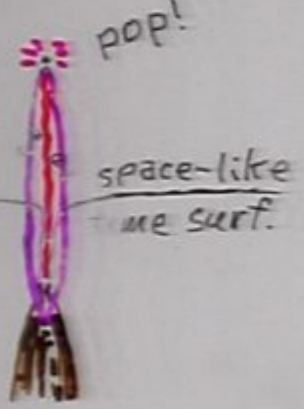

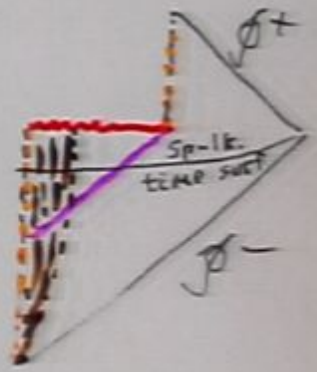

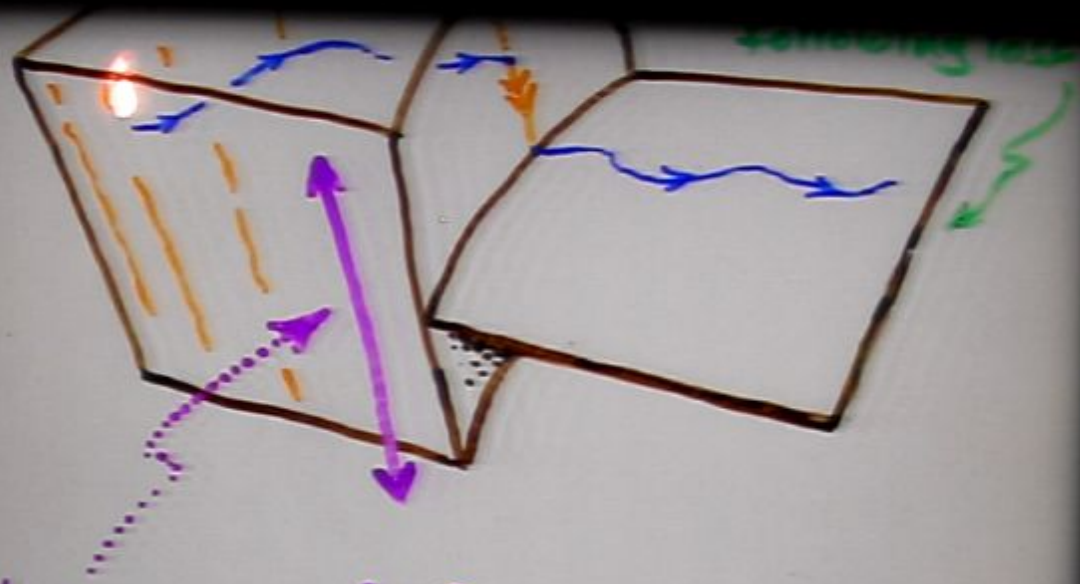

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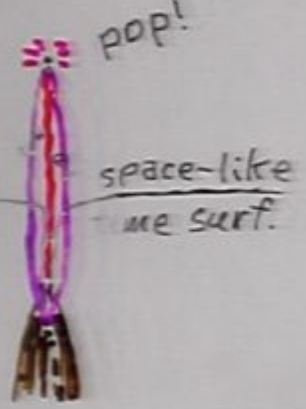

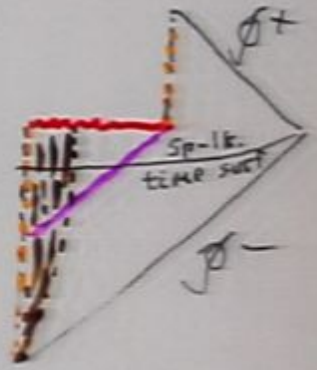

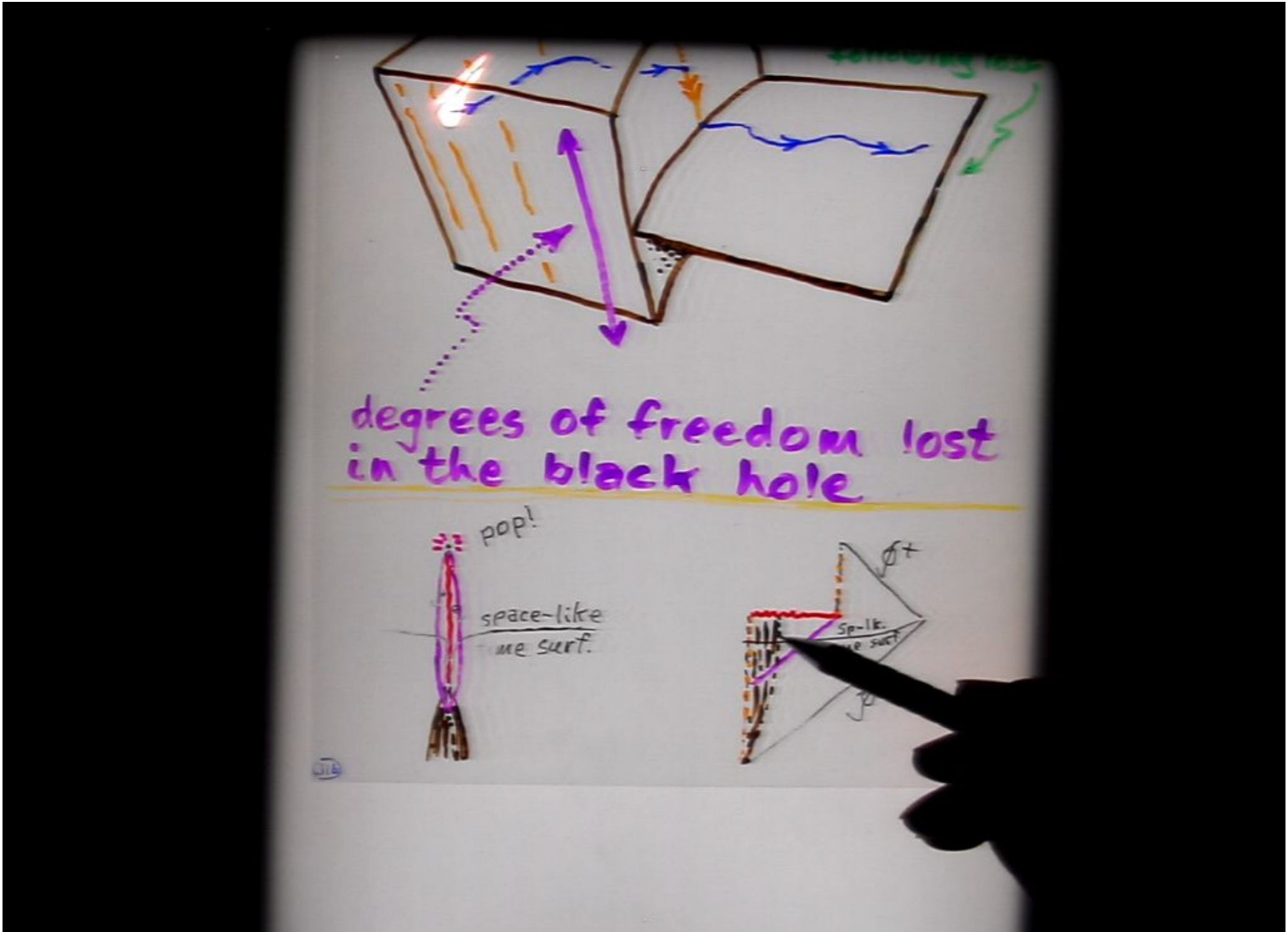
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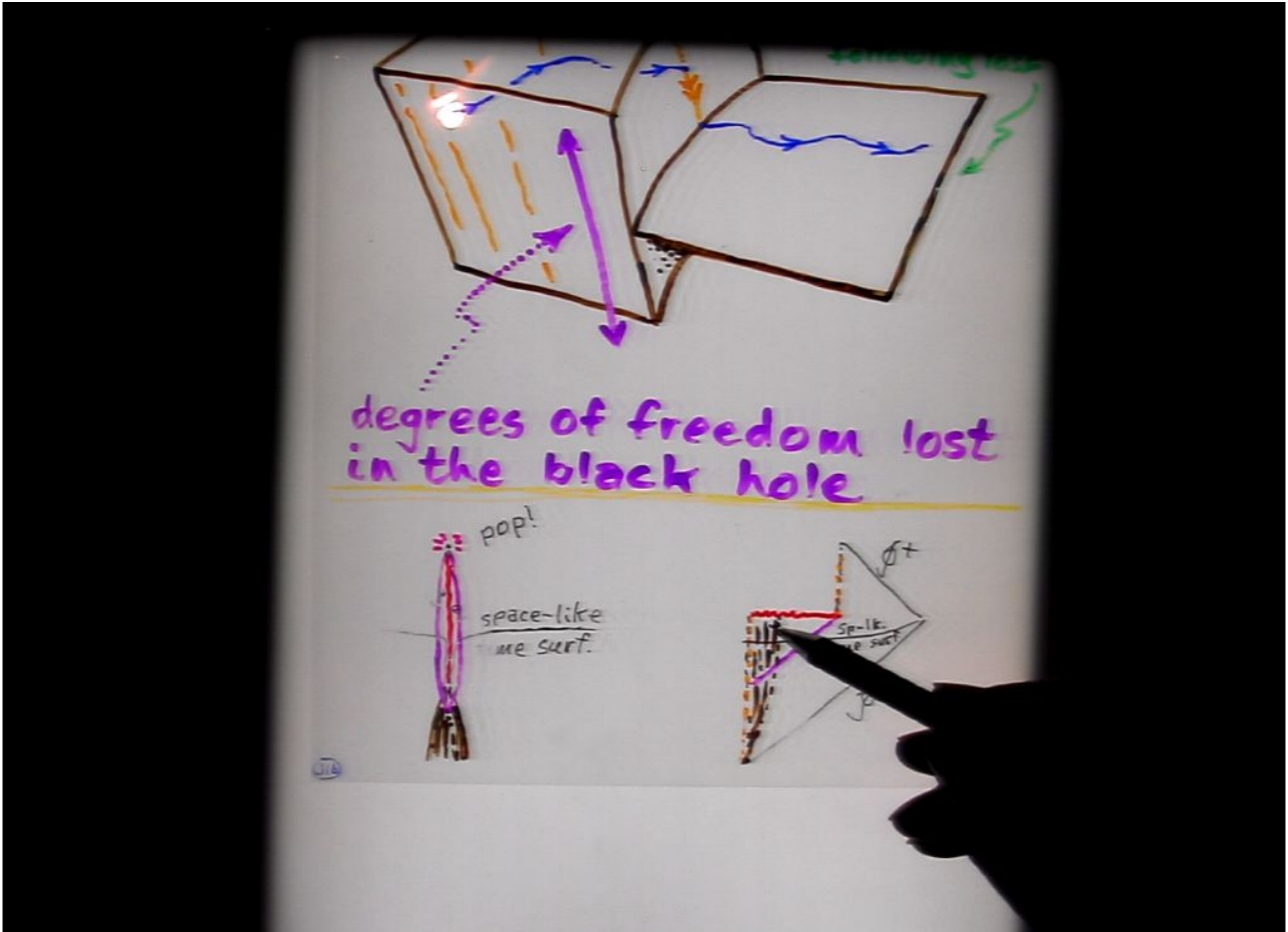
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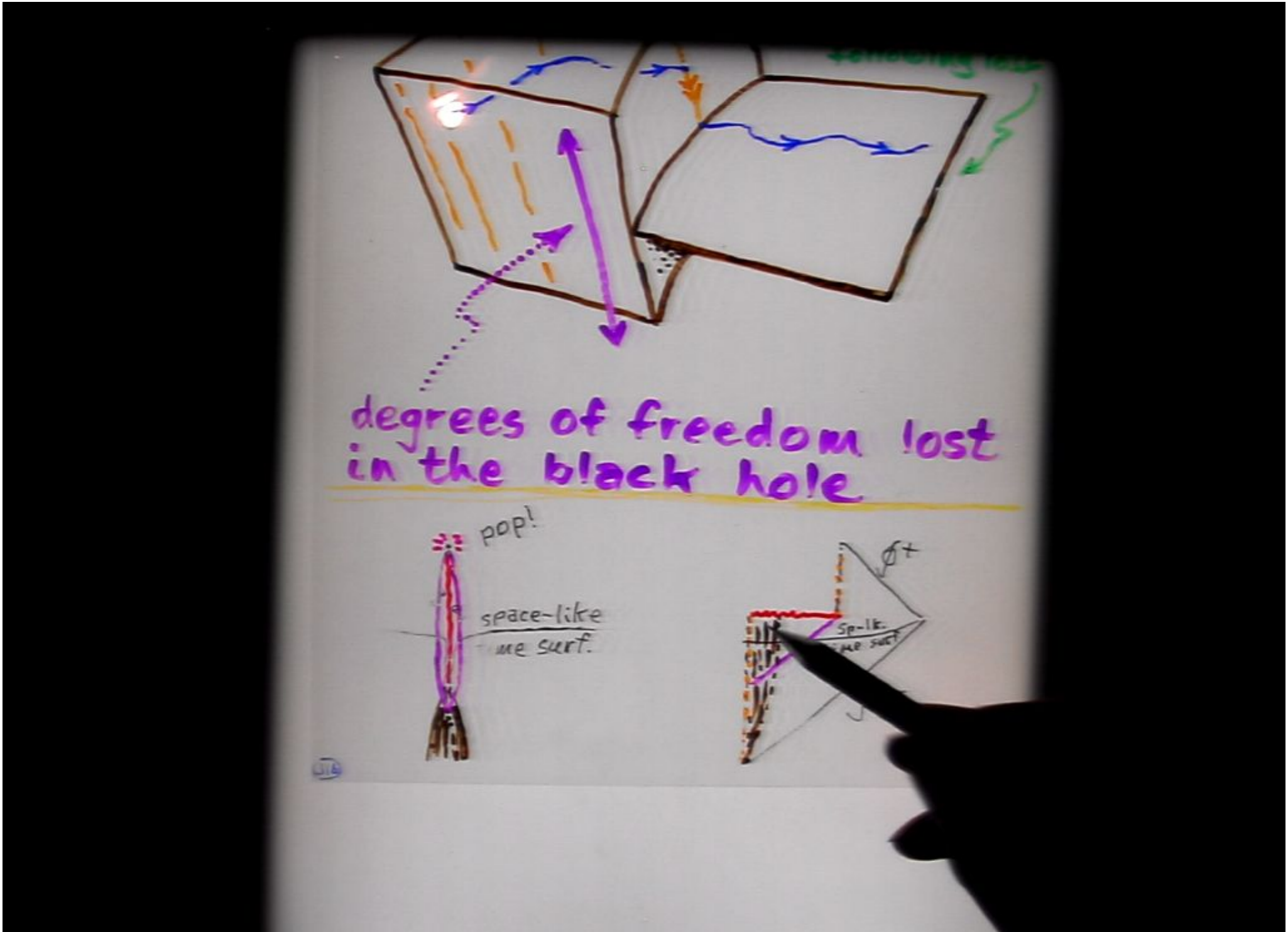
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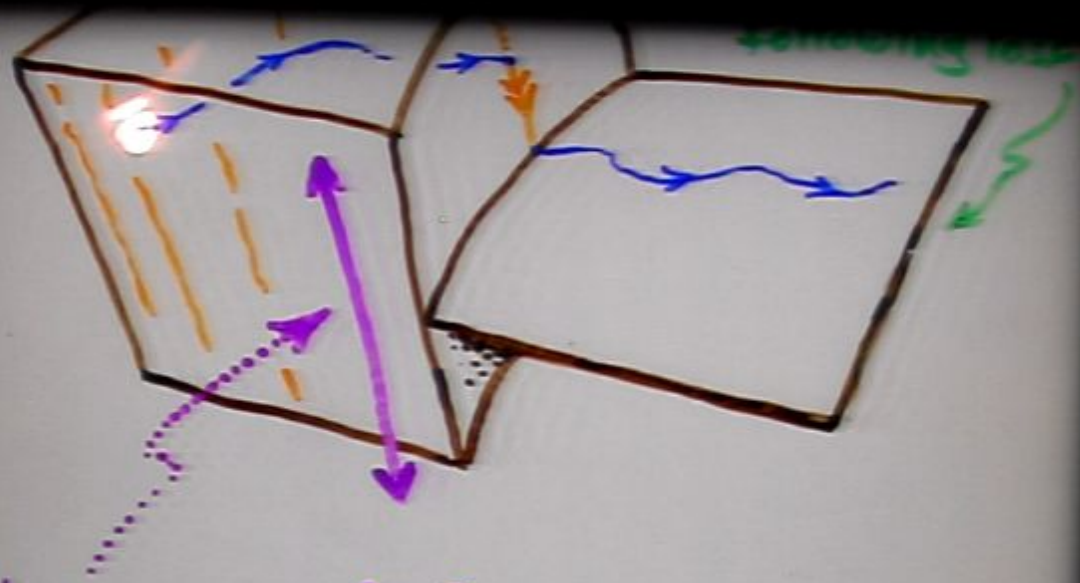

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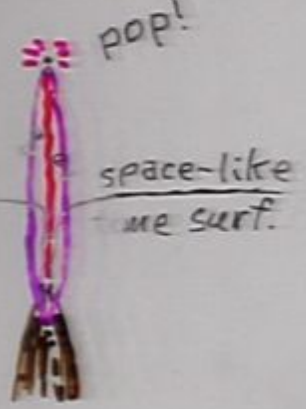

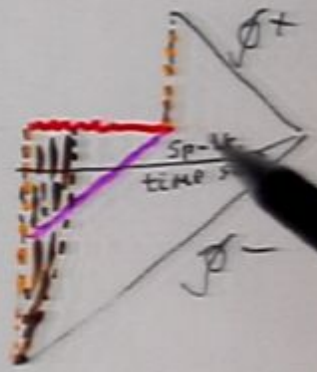

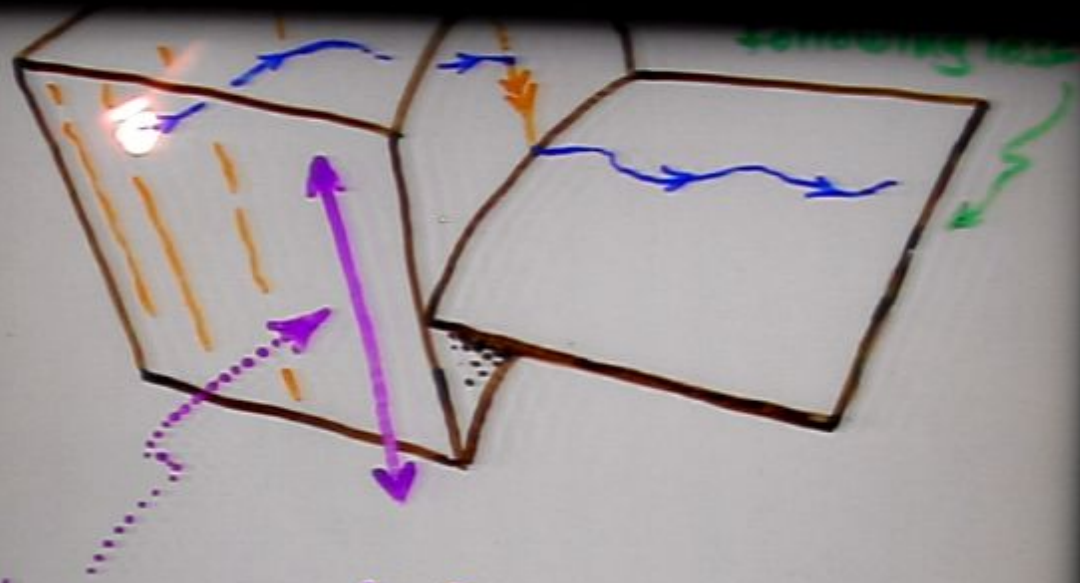

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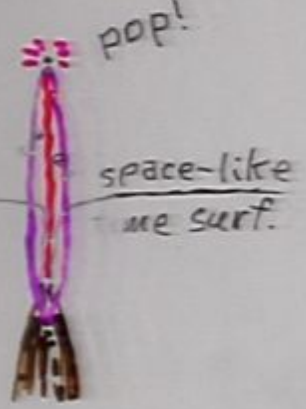

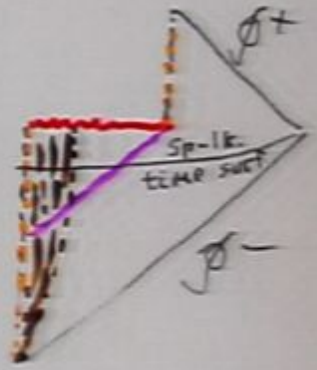

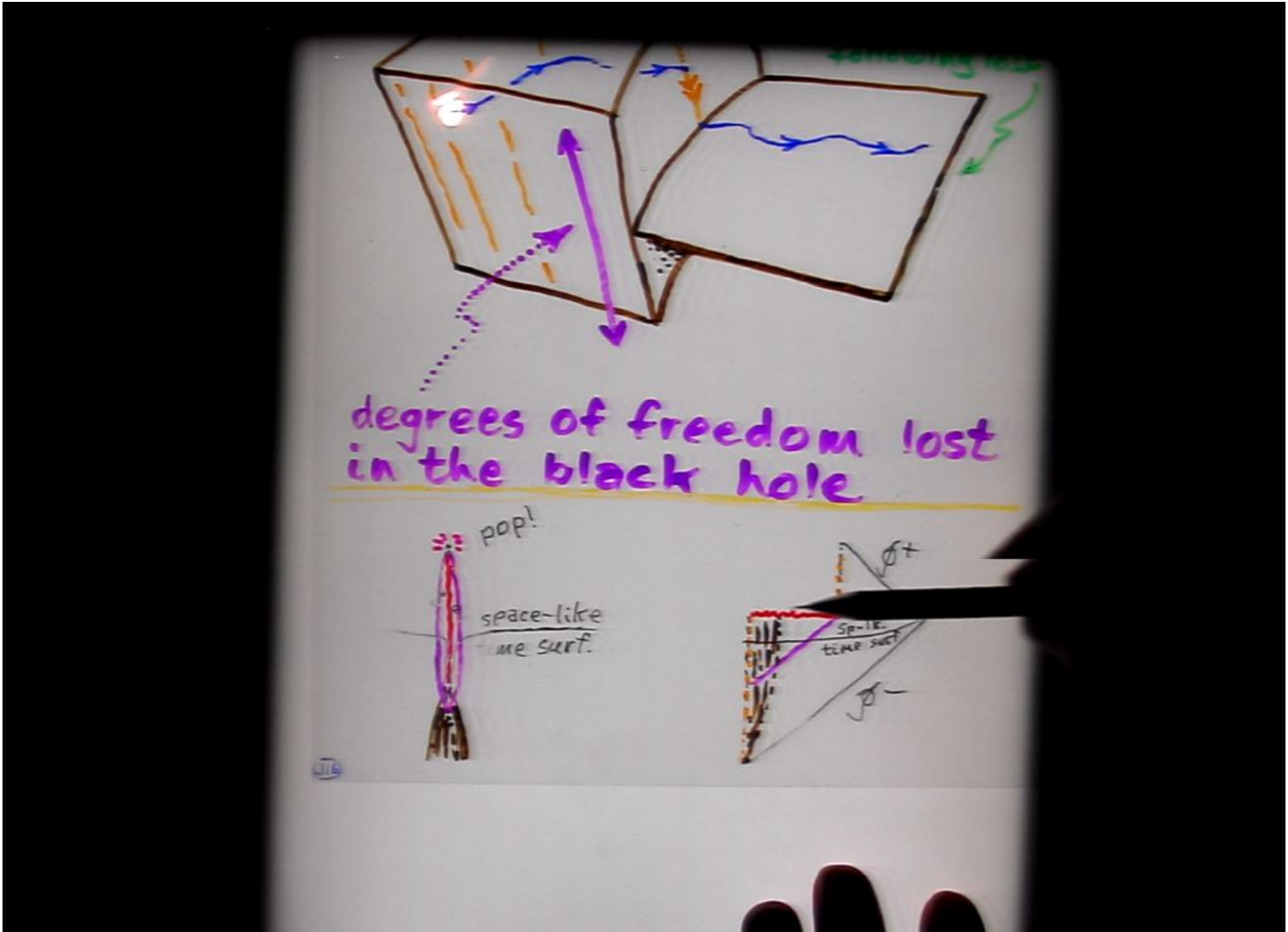
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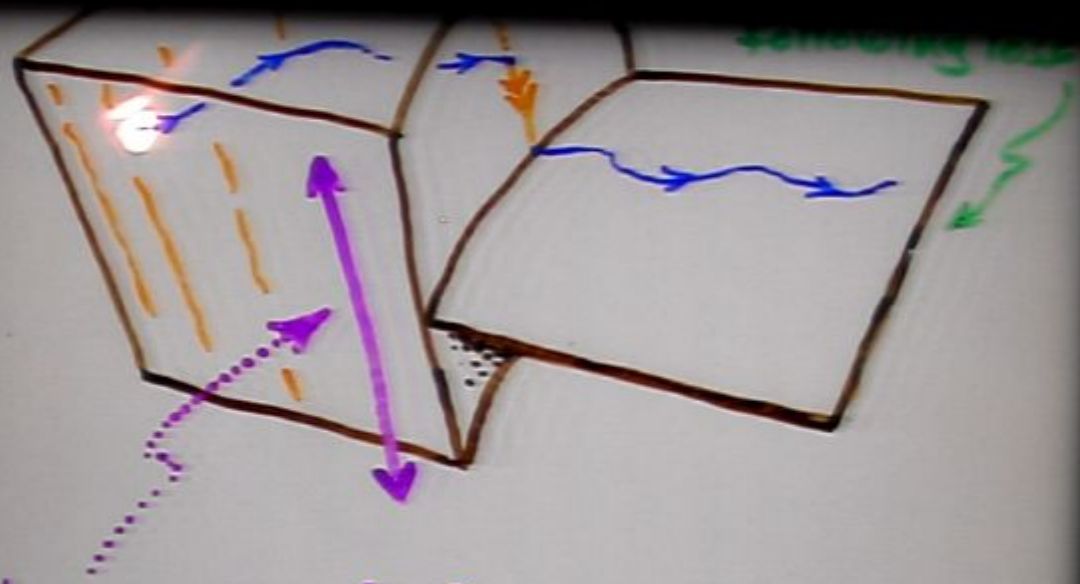
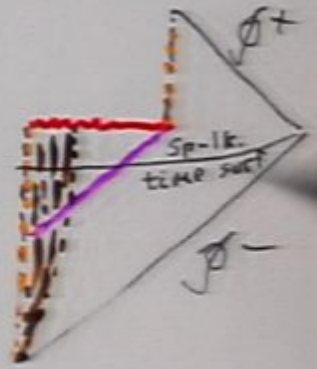
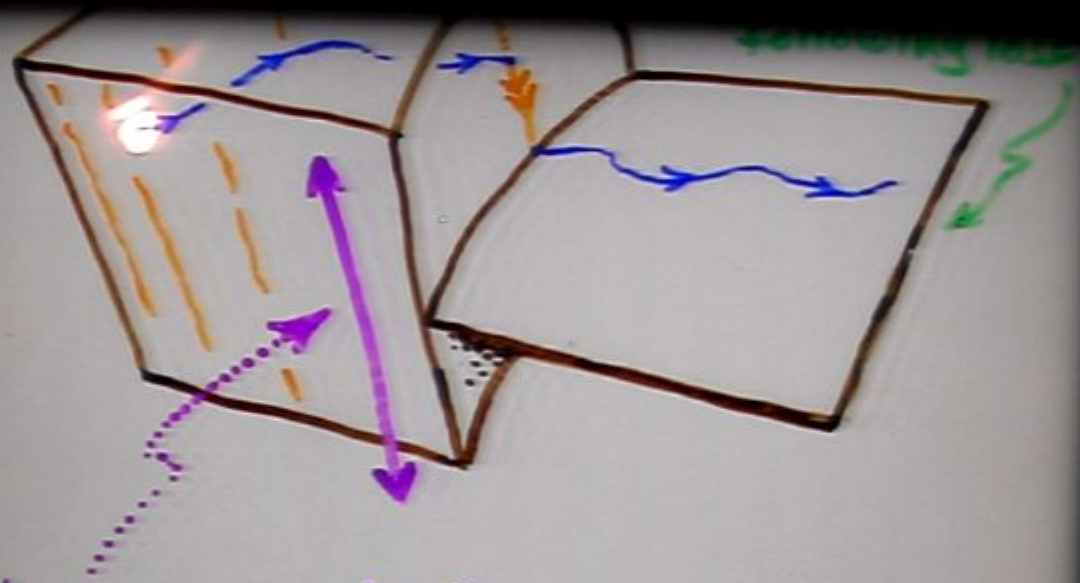


degrees of freedom lost in the black hole

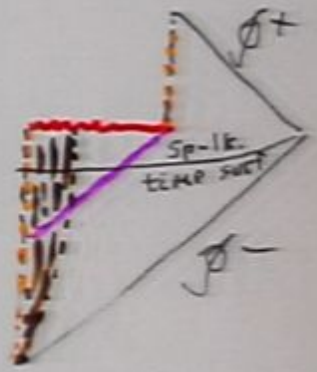


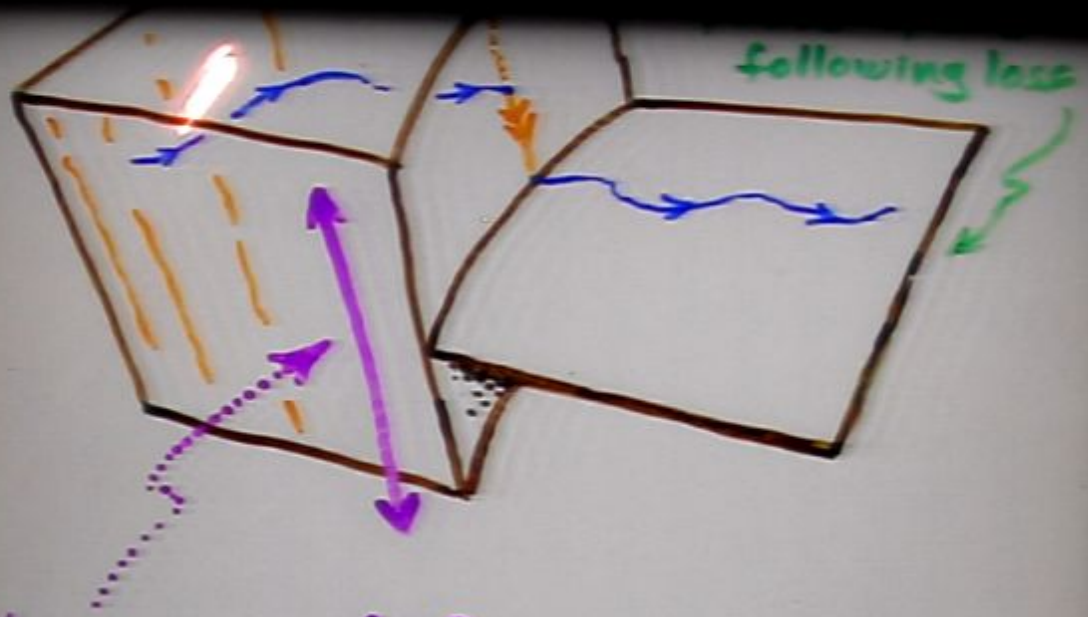




degrees of freedom lost in the black hole

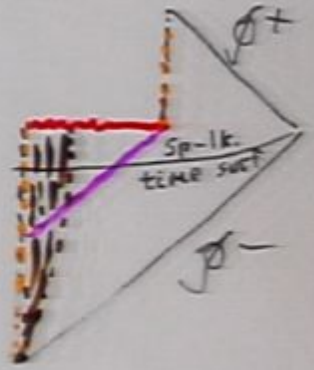


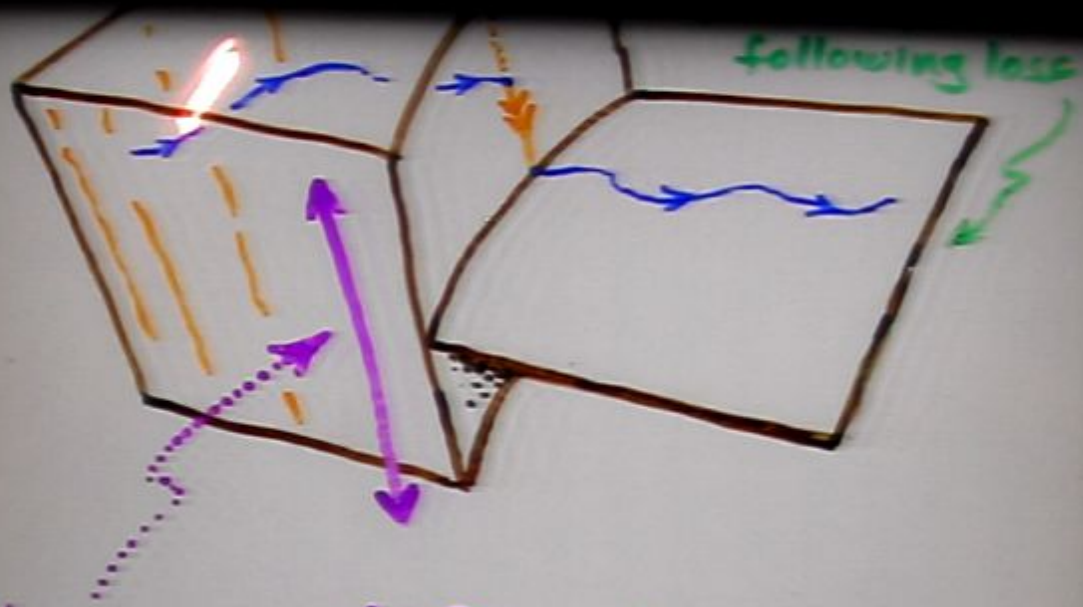




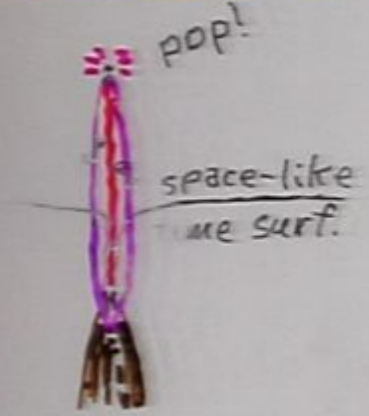
degrees of freedom lost in the black hole

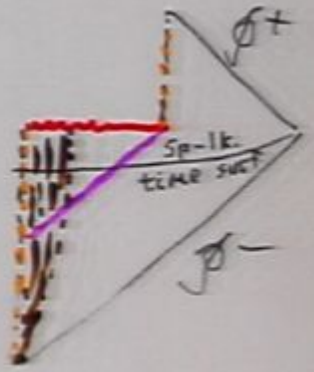


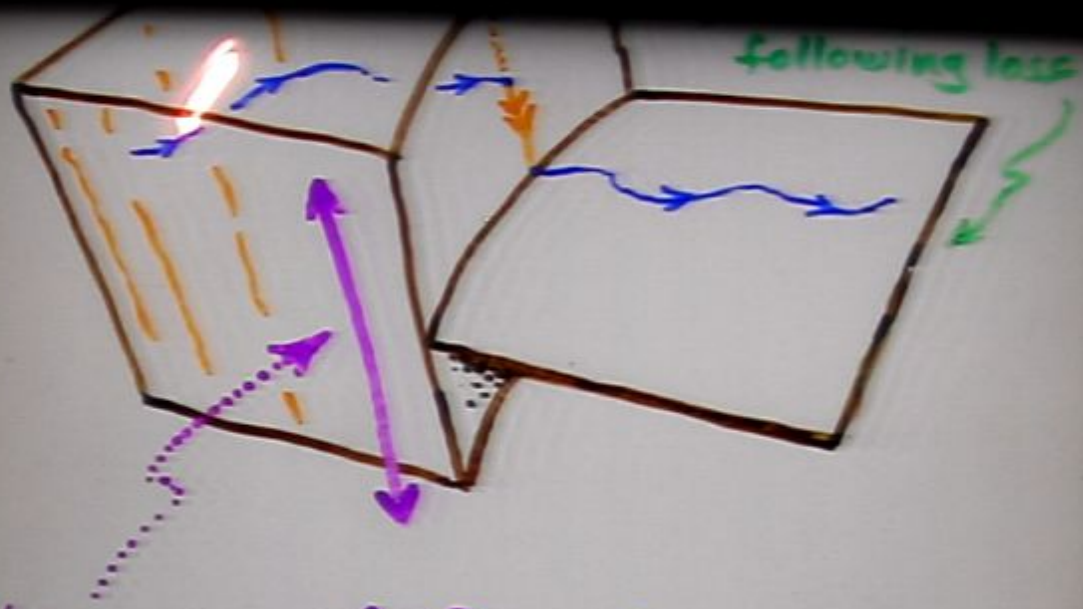




degrees of freedom lost in the black hole







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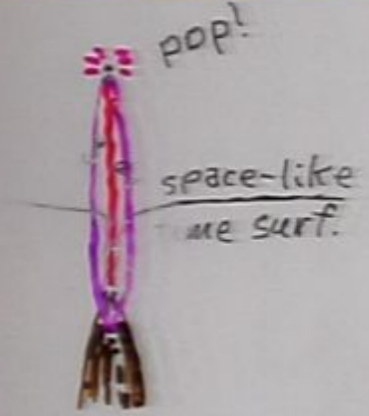

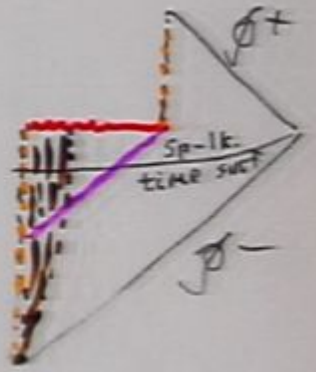

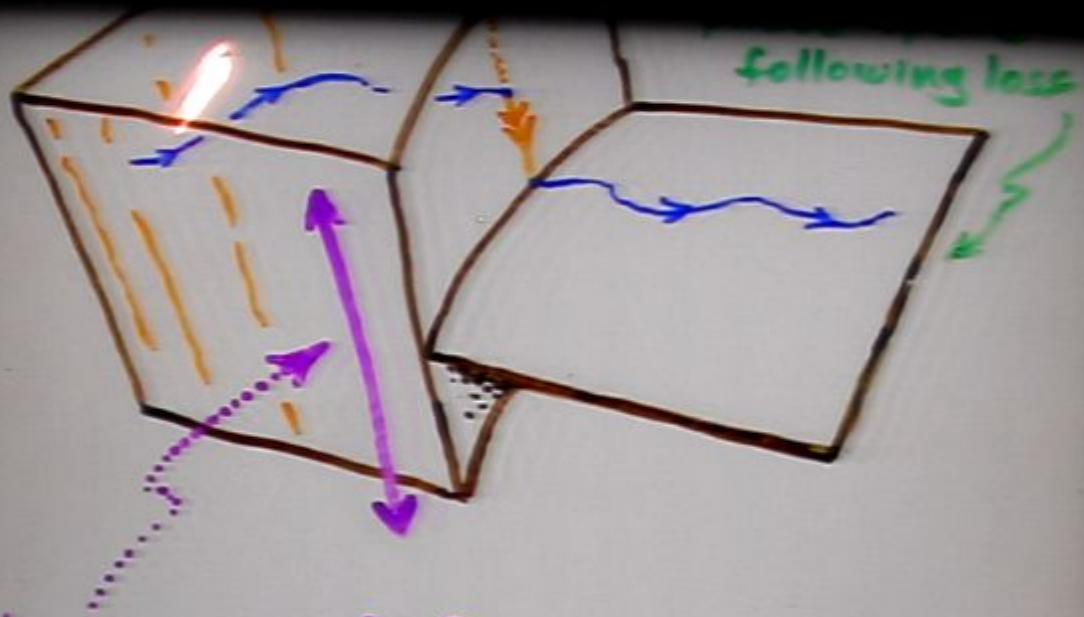

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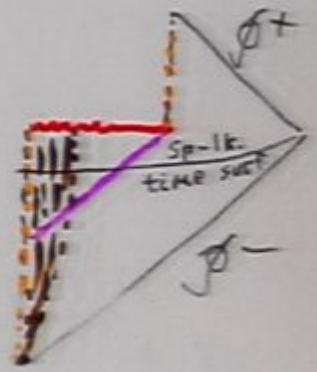

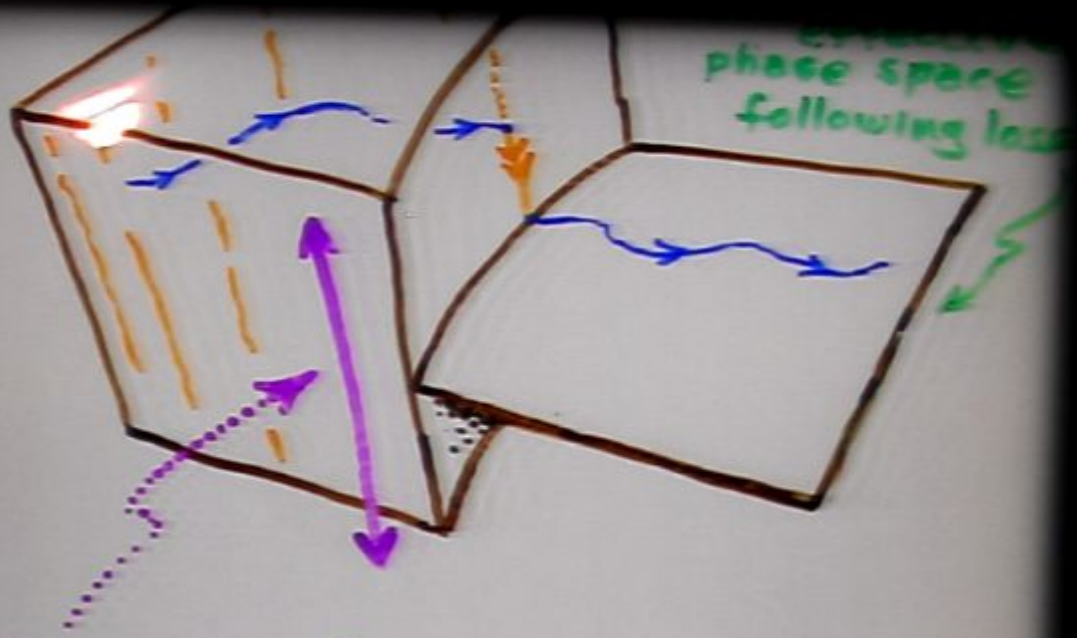

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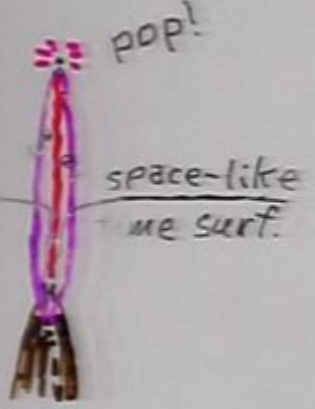
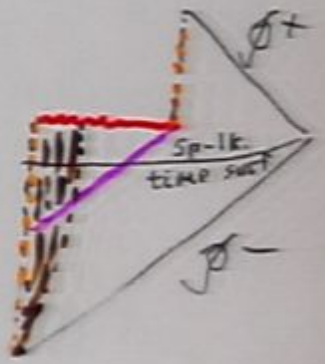
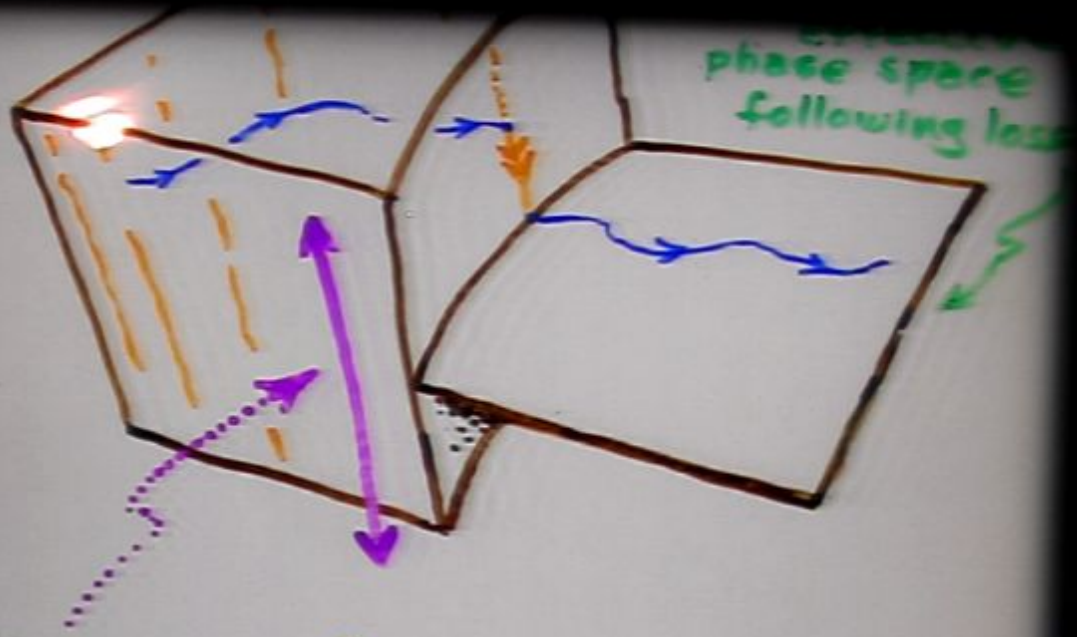
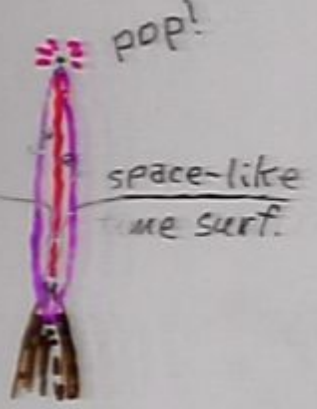
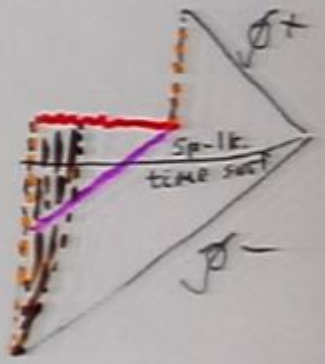


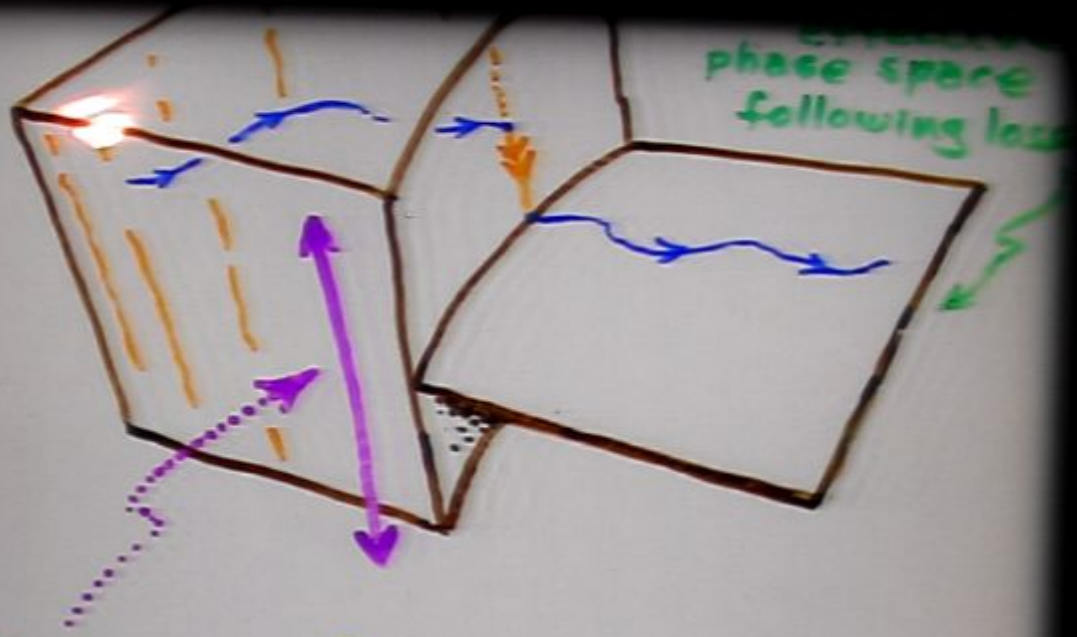




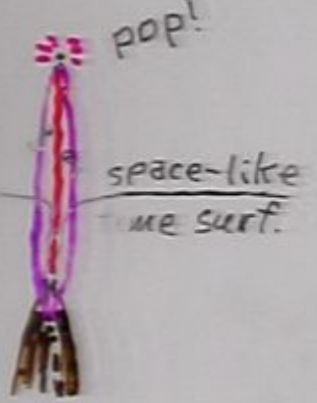
degrees of freedom lost in the black hole

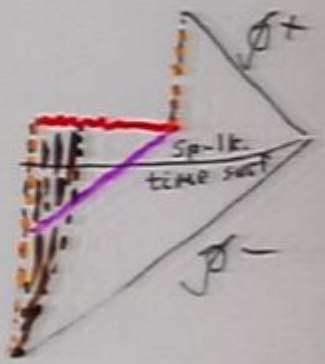


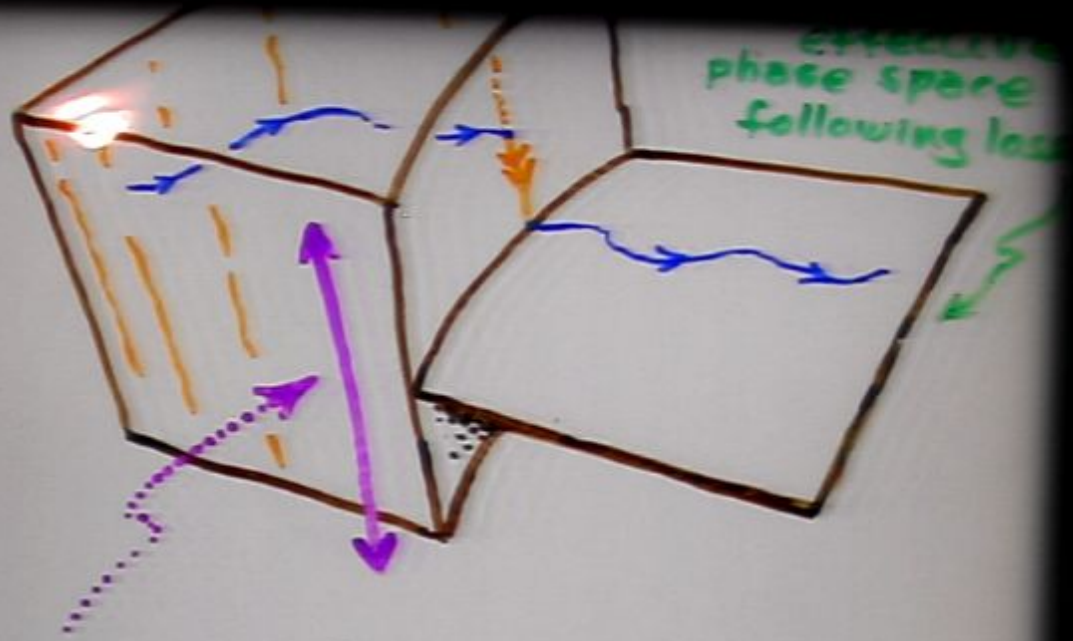




degrees of freedom lost in the black hole







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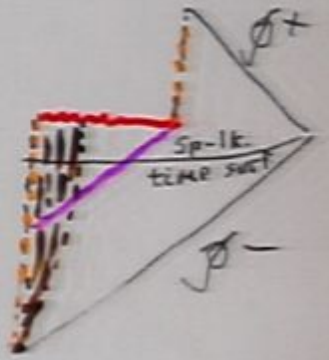

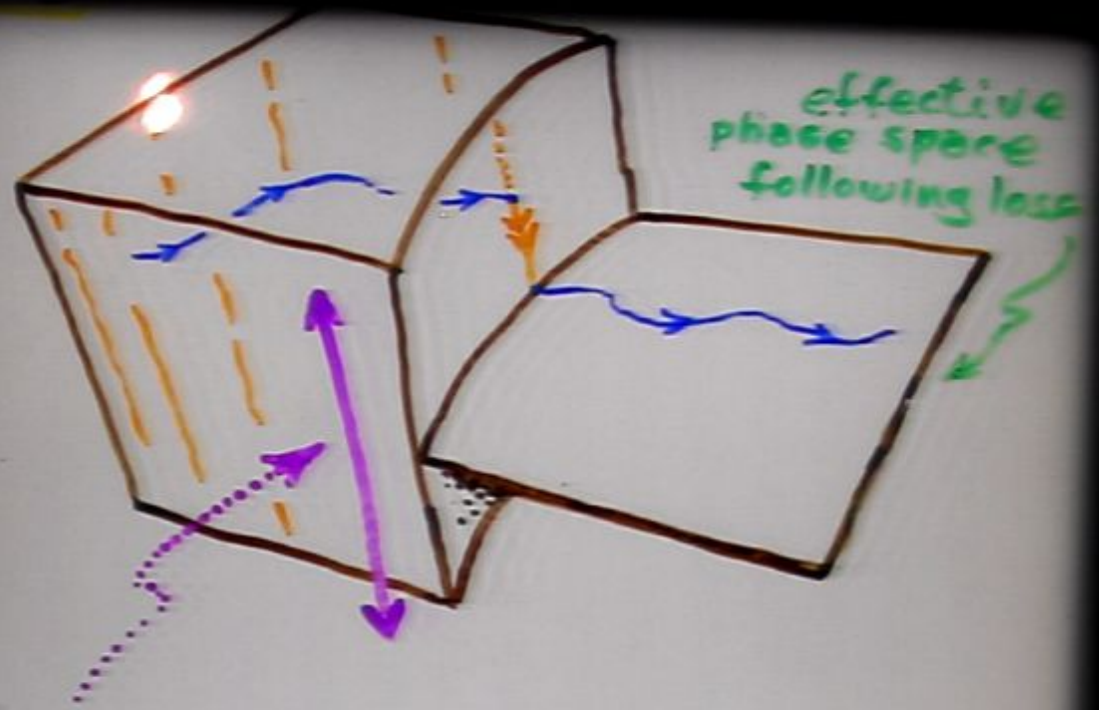

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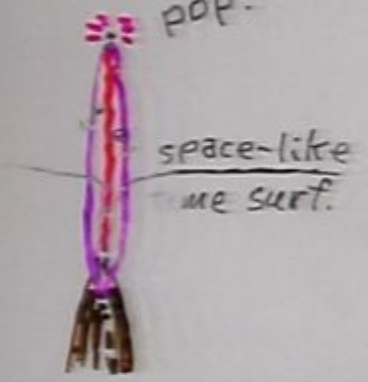
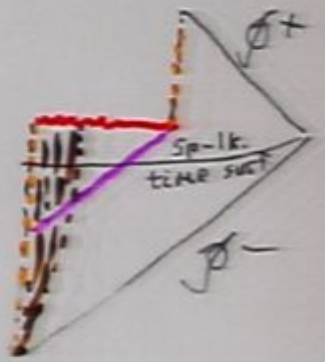
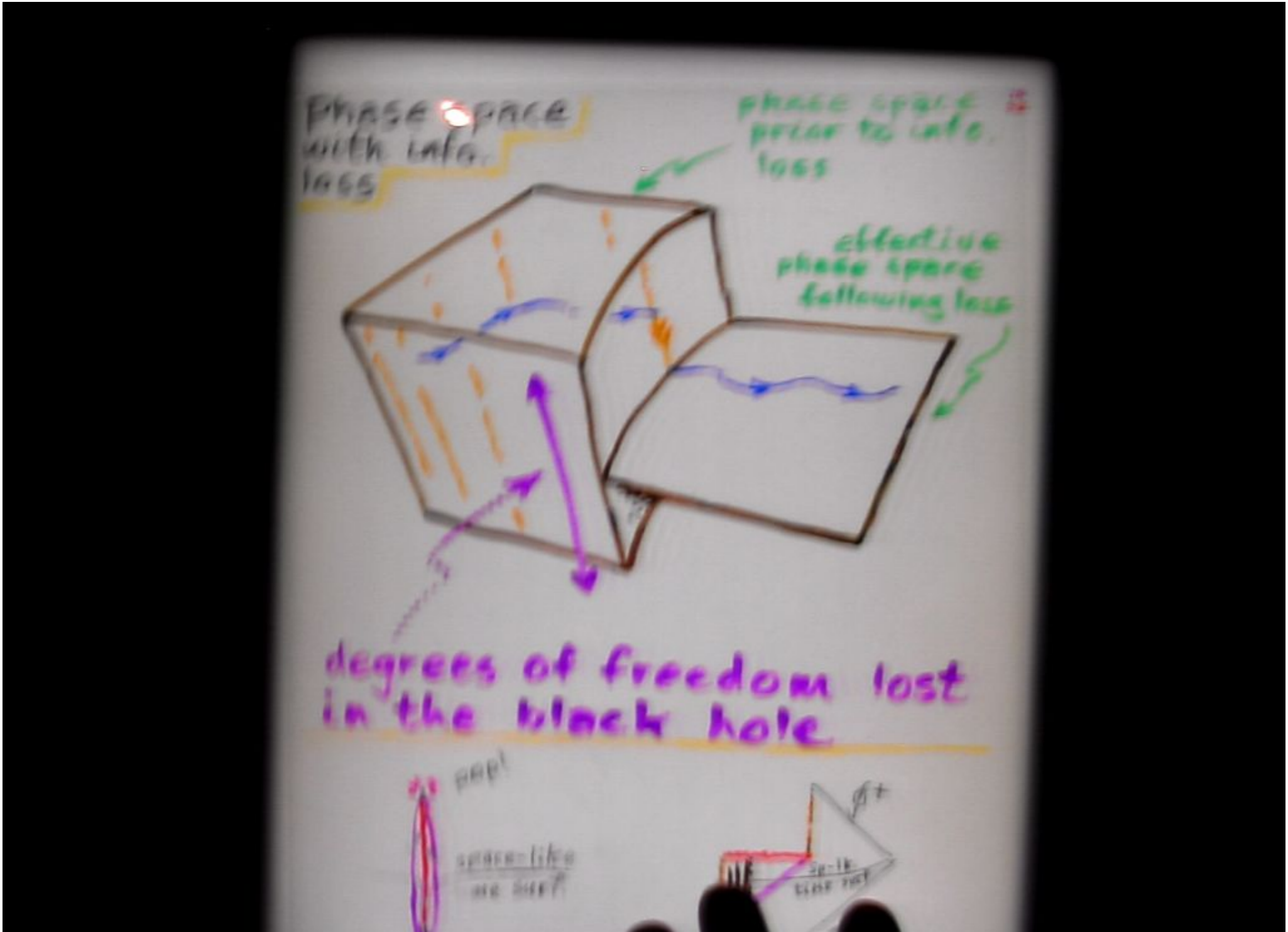
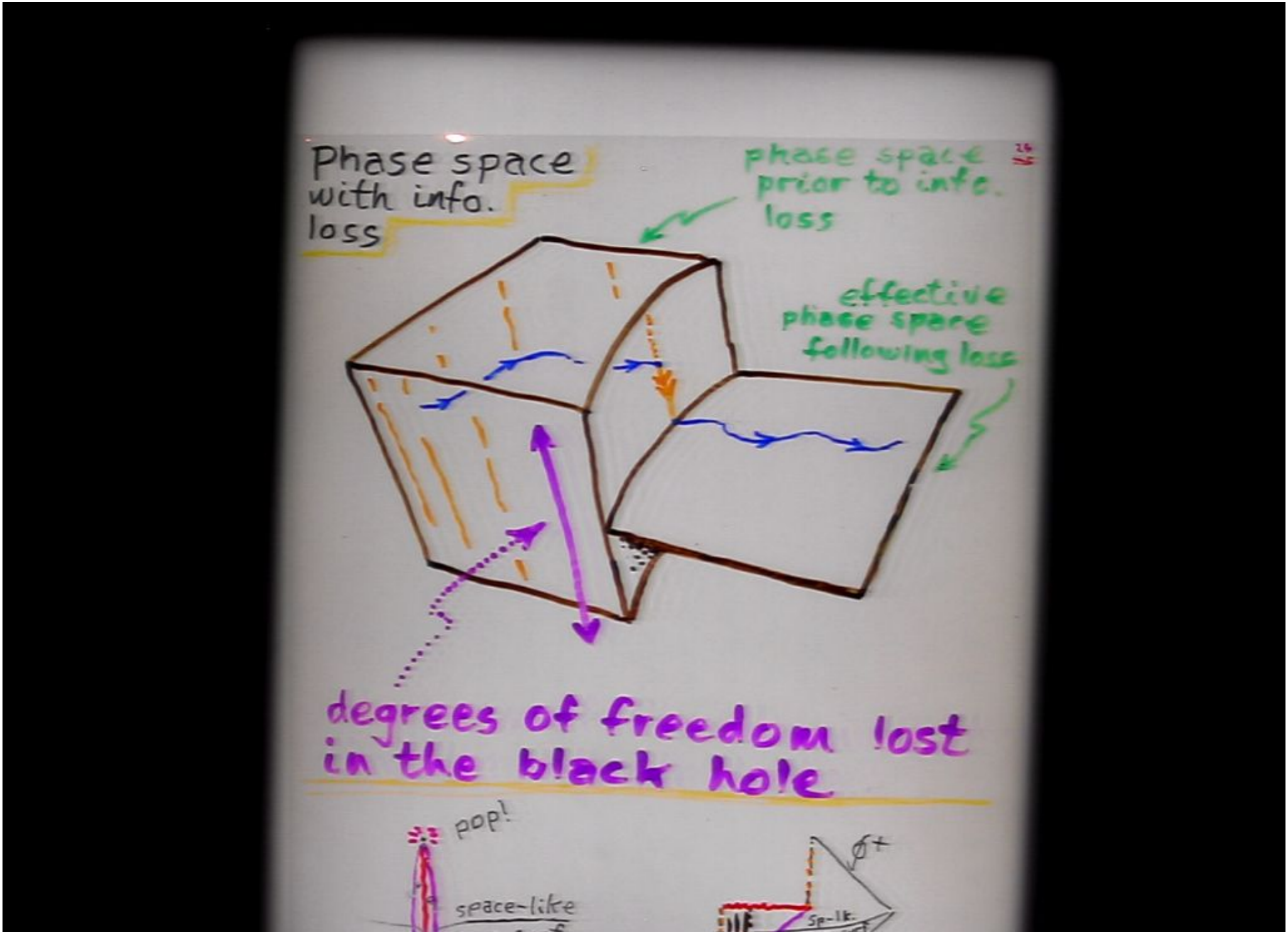




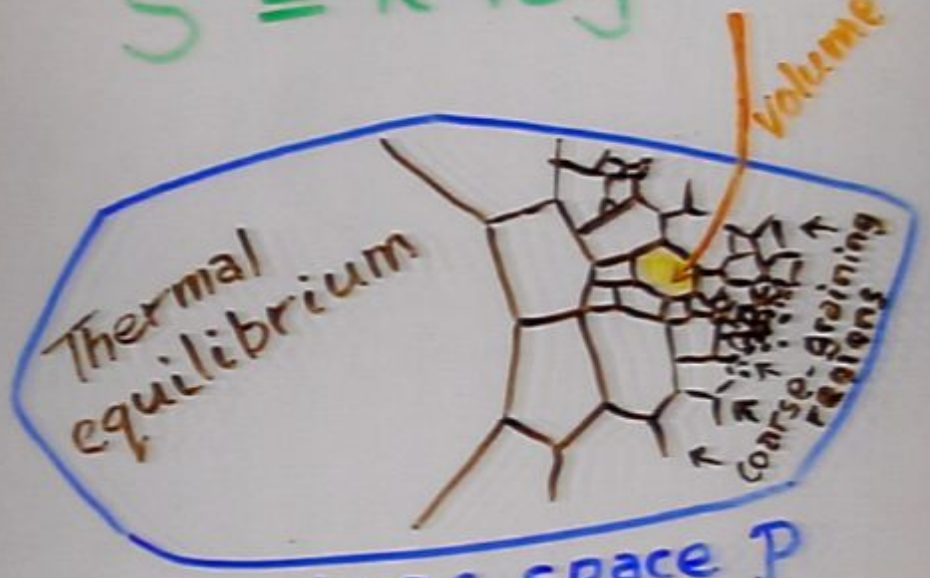

Phase space with info. loss
phase space prior to info. loss
effective phase space following loss
degrees of freedom lost in the black hole
pop!


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!
space-like

Boltzmann

of ENTROPY

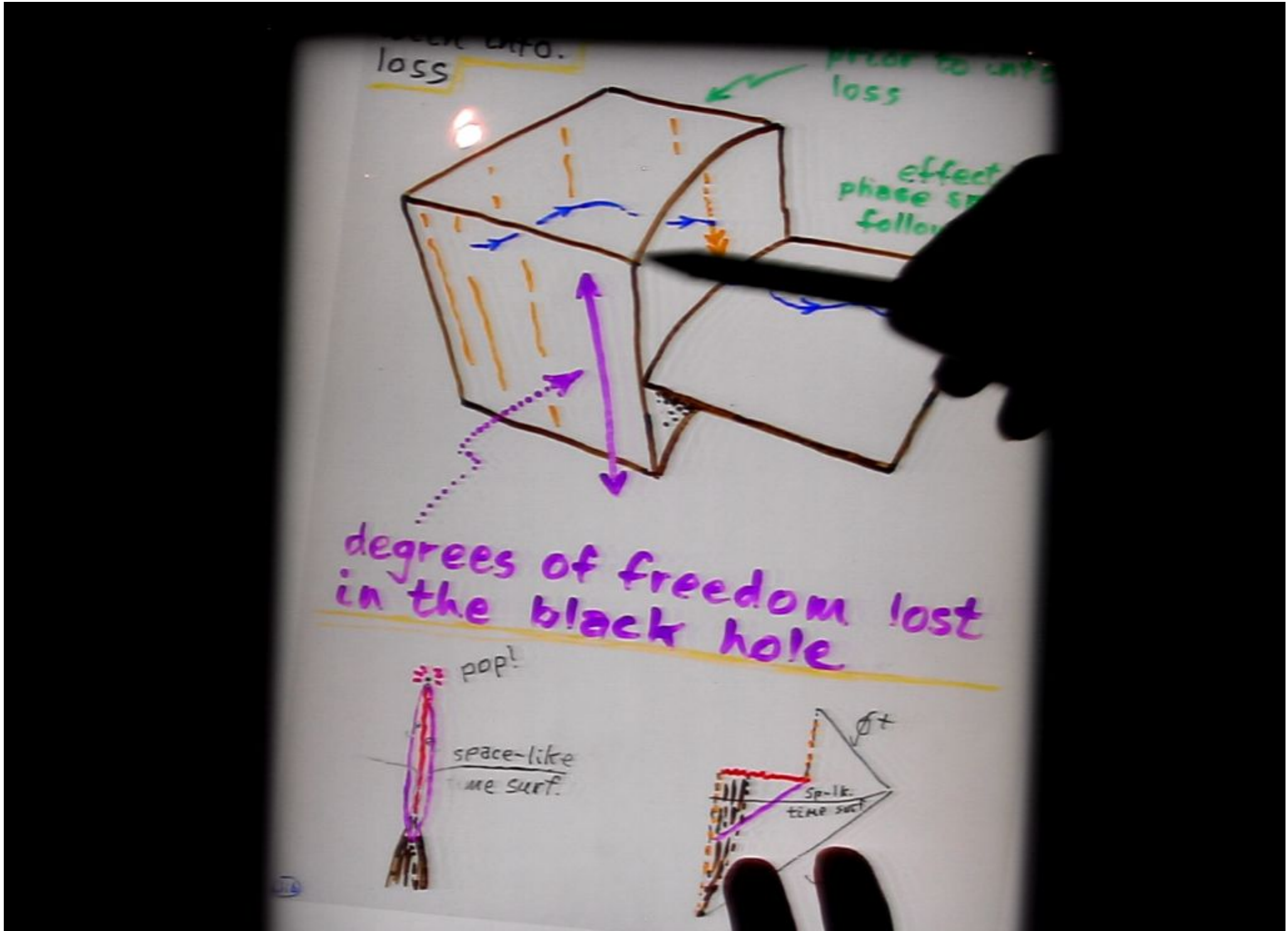
$$S = k \log V$$

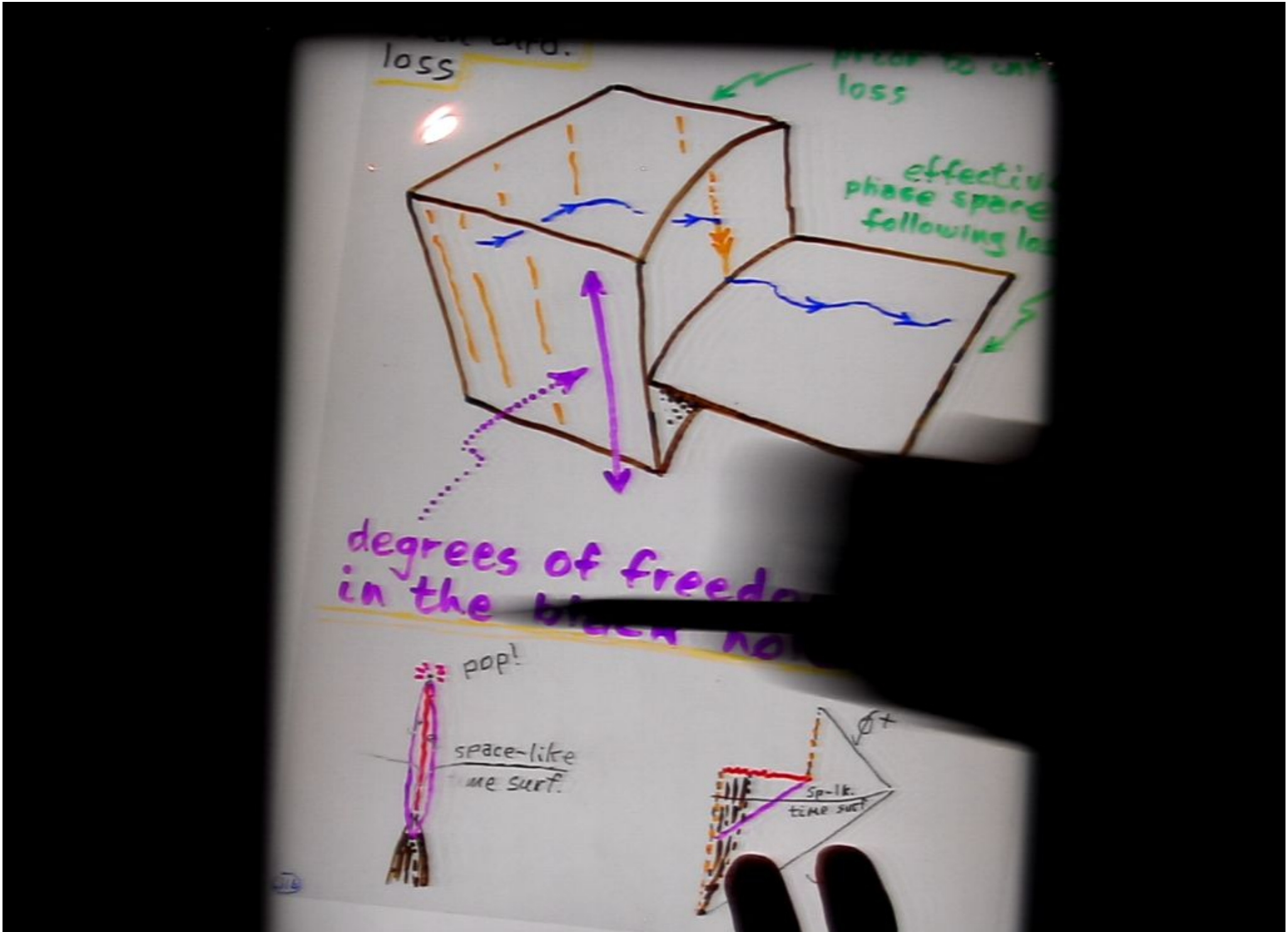


Note: $\log(VW) = \log V + \log W$

so entropy is additive

for independent systems


loss
loss
degrees of freedom lost
in the black hole
pop!
space-like
me surf.
Sp-lk.
time surf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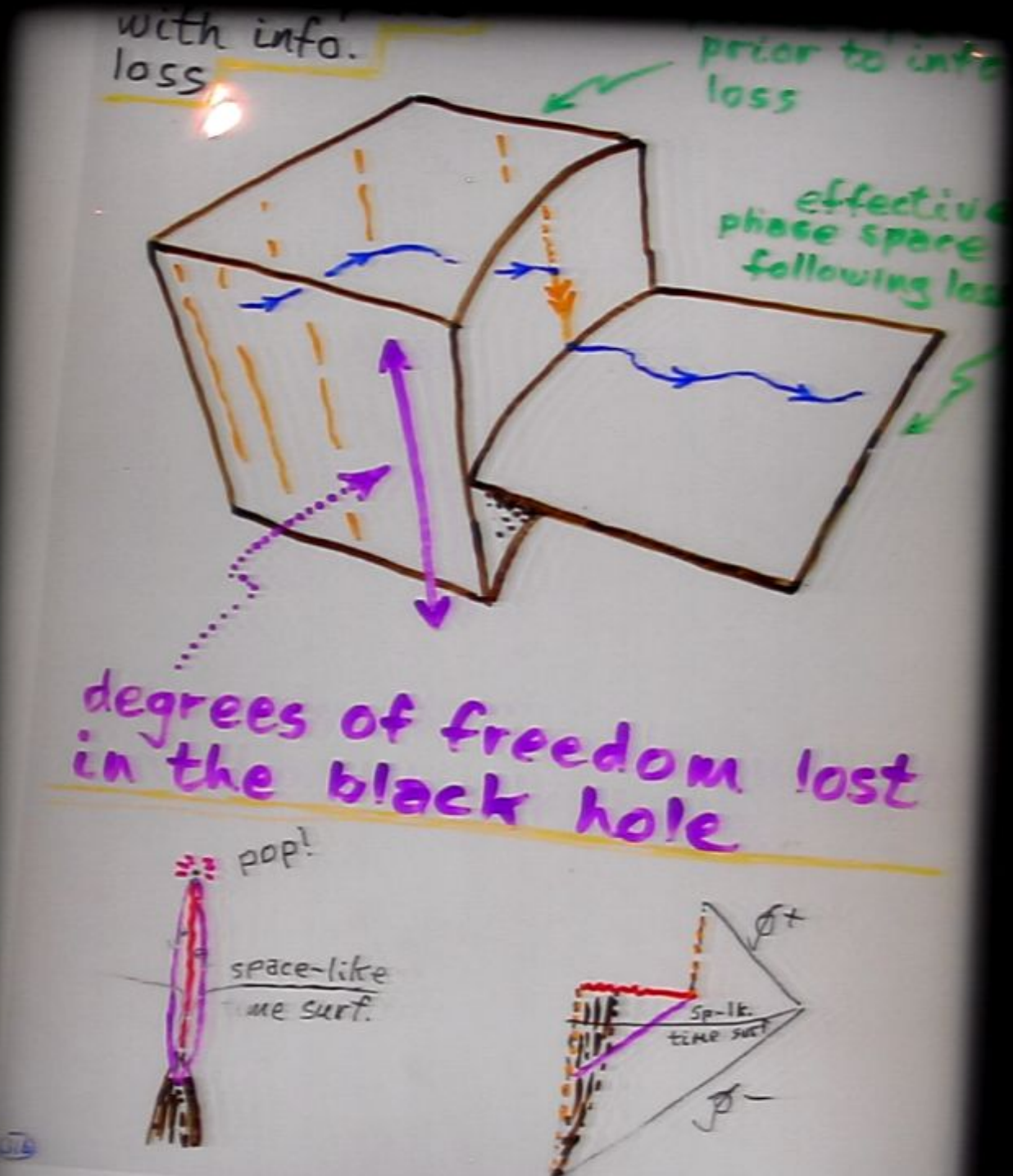
with info.
loss
prior to info
loss
effective
phase space
following los
degrees of freedom lost
in the black hole
pop!
space-like
me surf.
Sp-lk.
time surf.

with info. loss

prior to info loss

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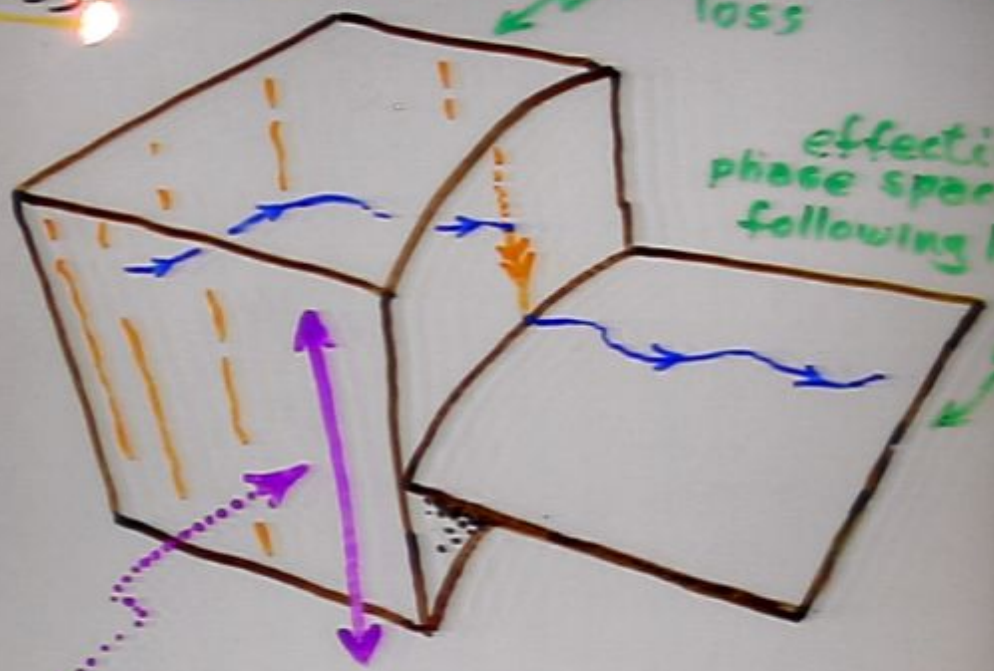
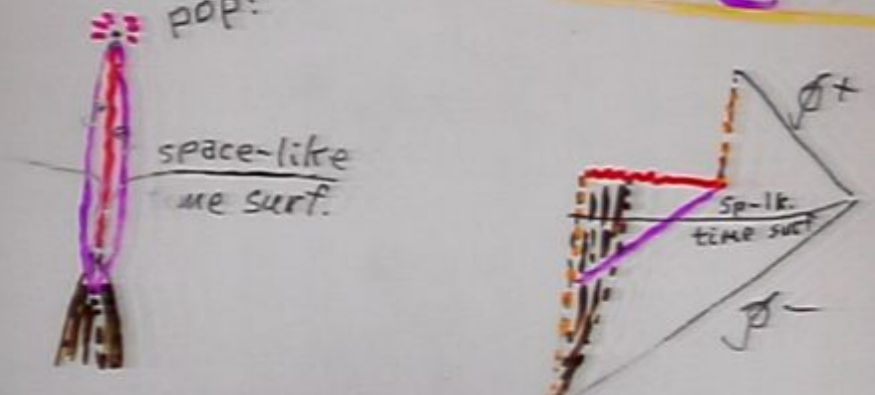


degrees of freedom lost in the black hole



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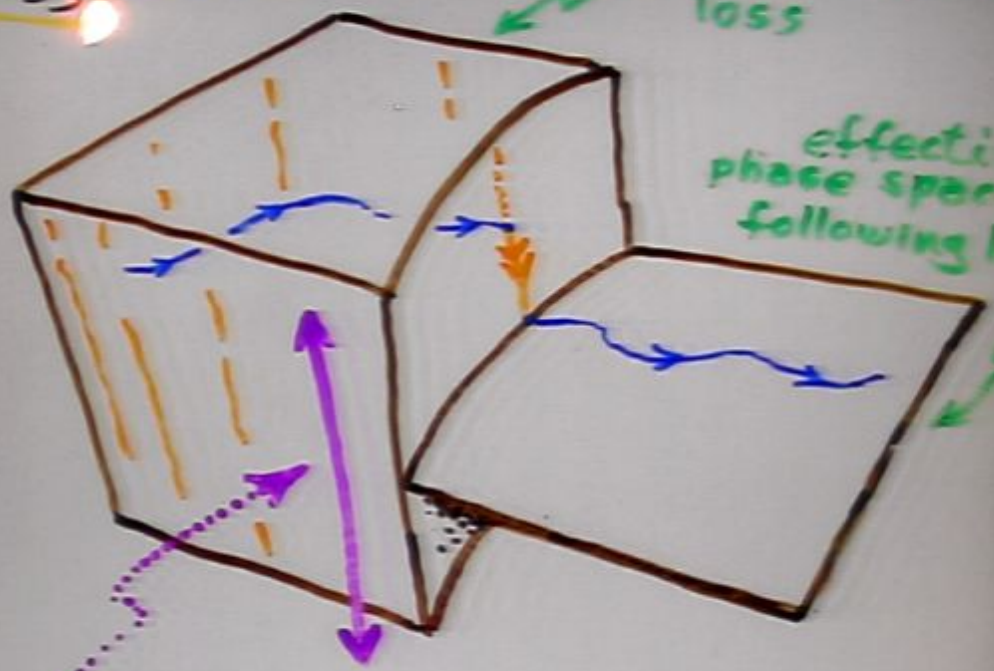
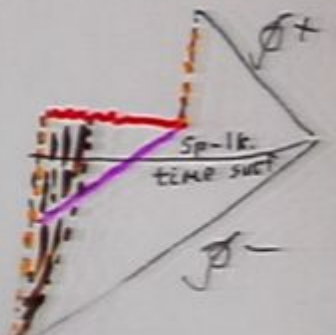
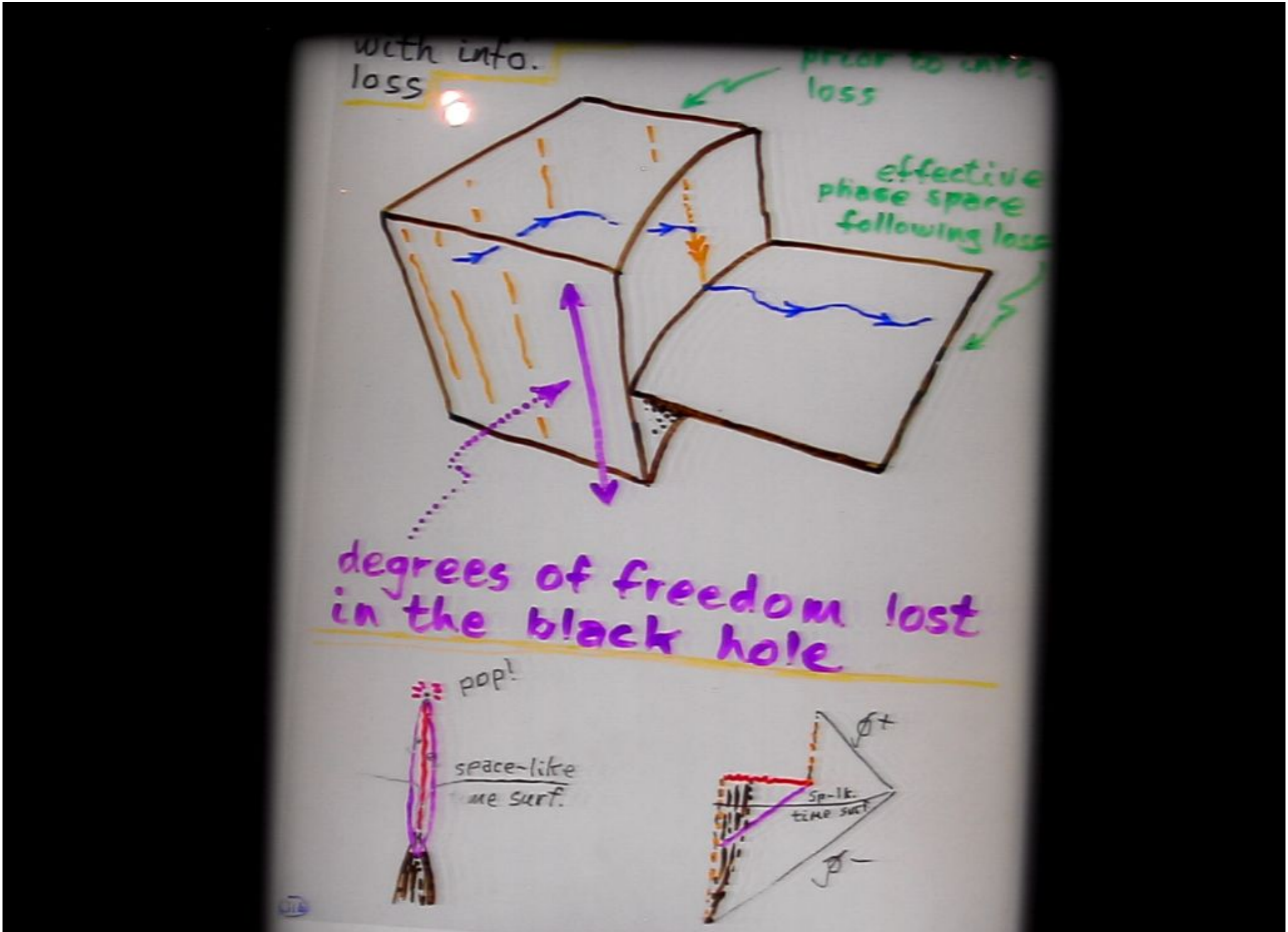


degrees of freedom lost
in the black hole



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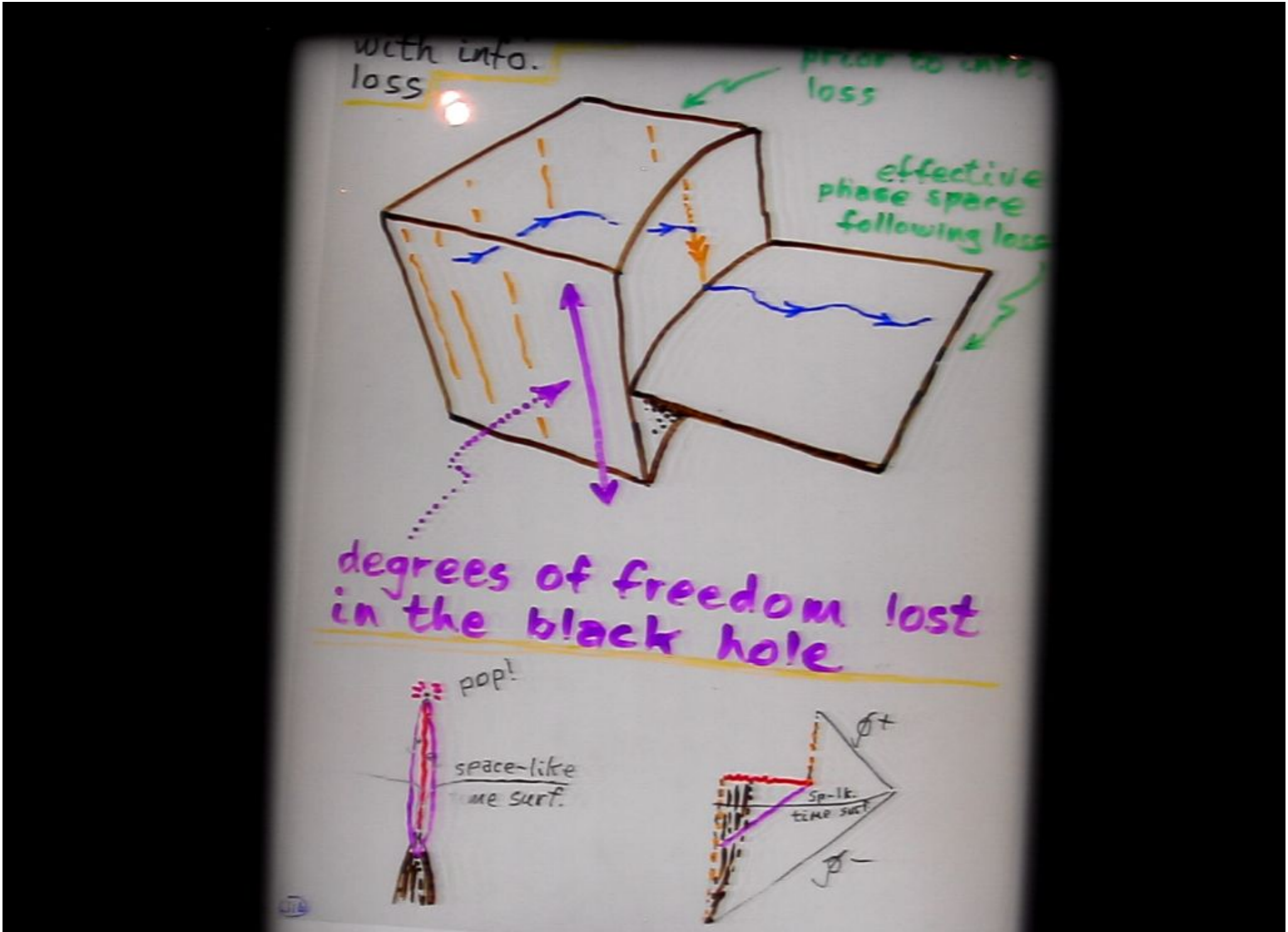
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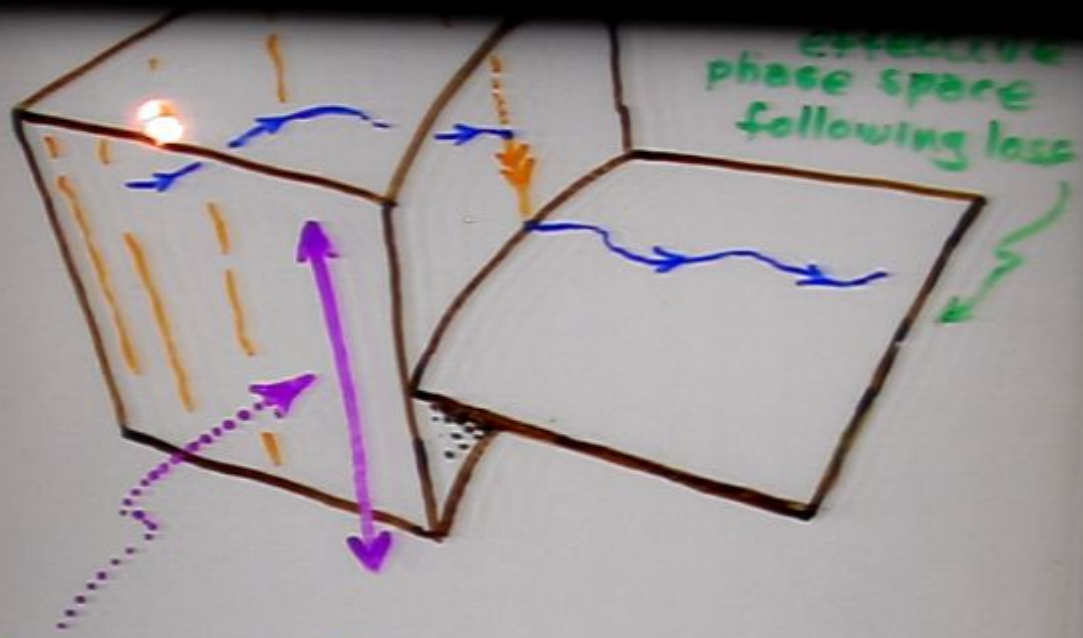
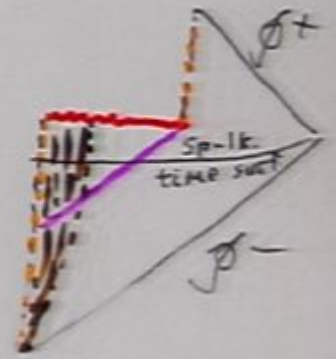
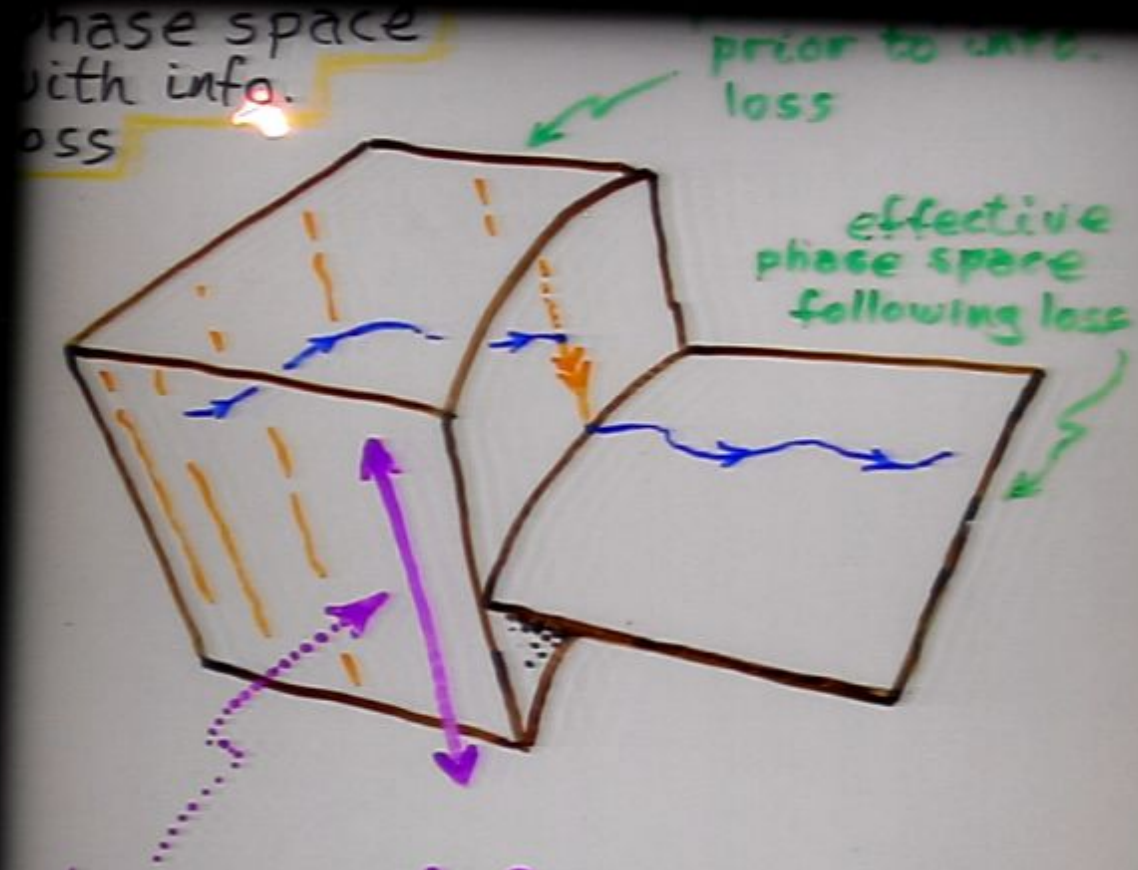


degrees of freedom lost in the black hole







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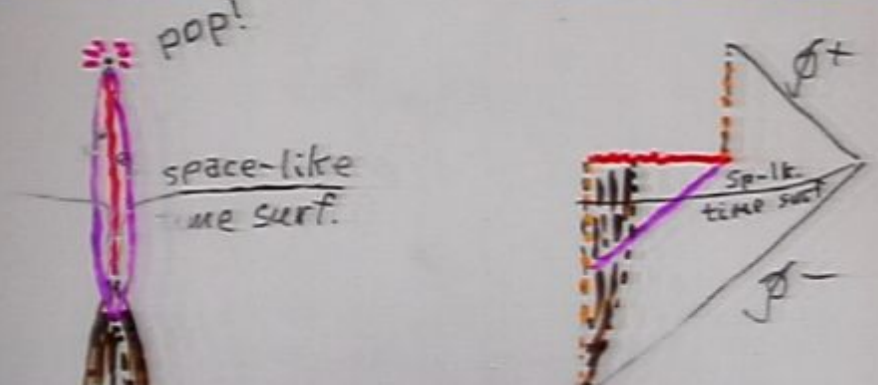

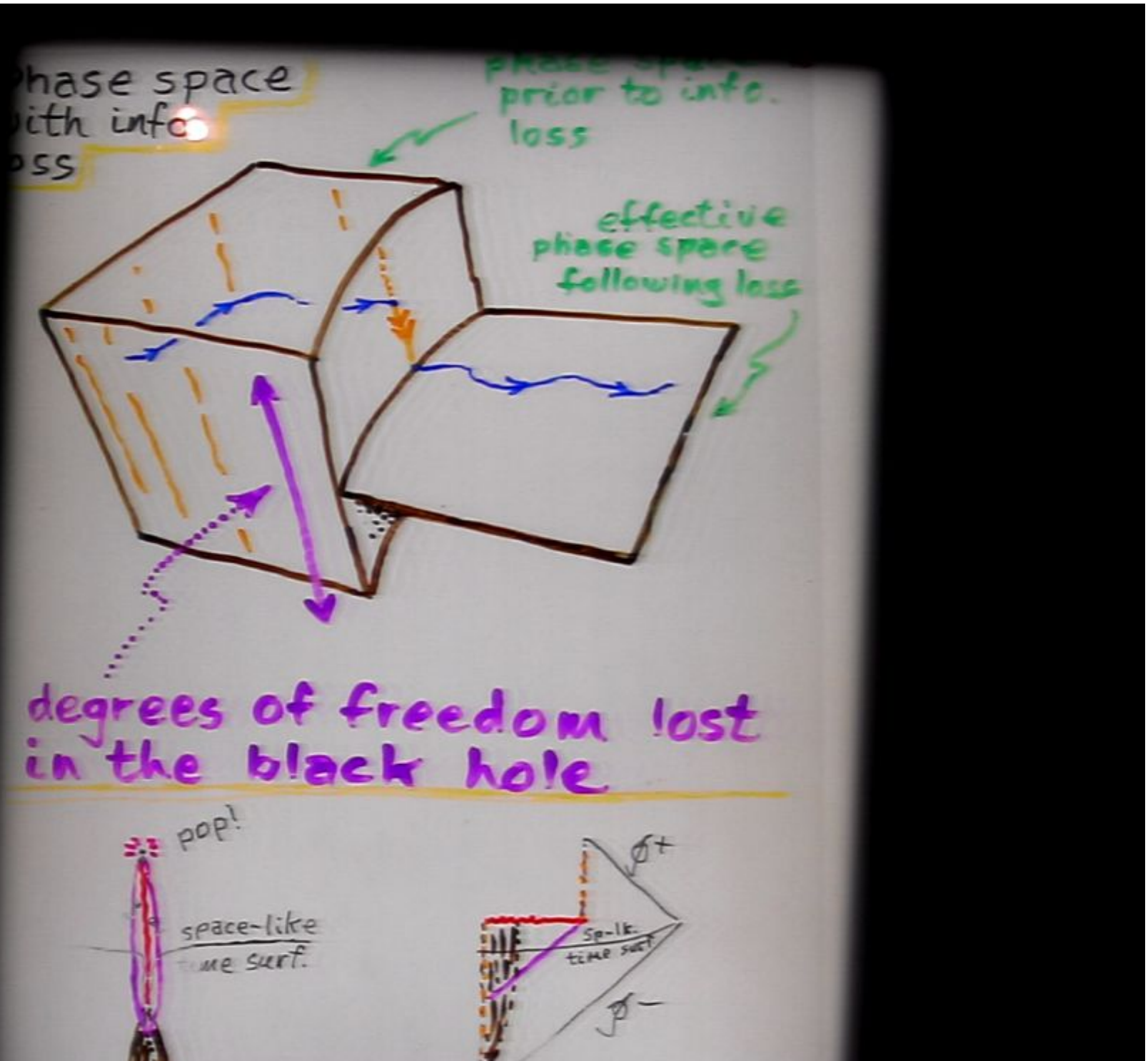
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degrees of freedom lost
in the black hole
pop!
space-like
me surf.
Sp-lk.
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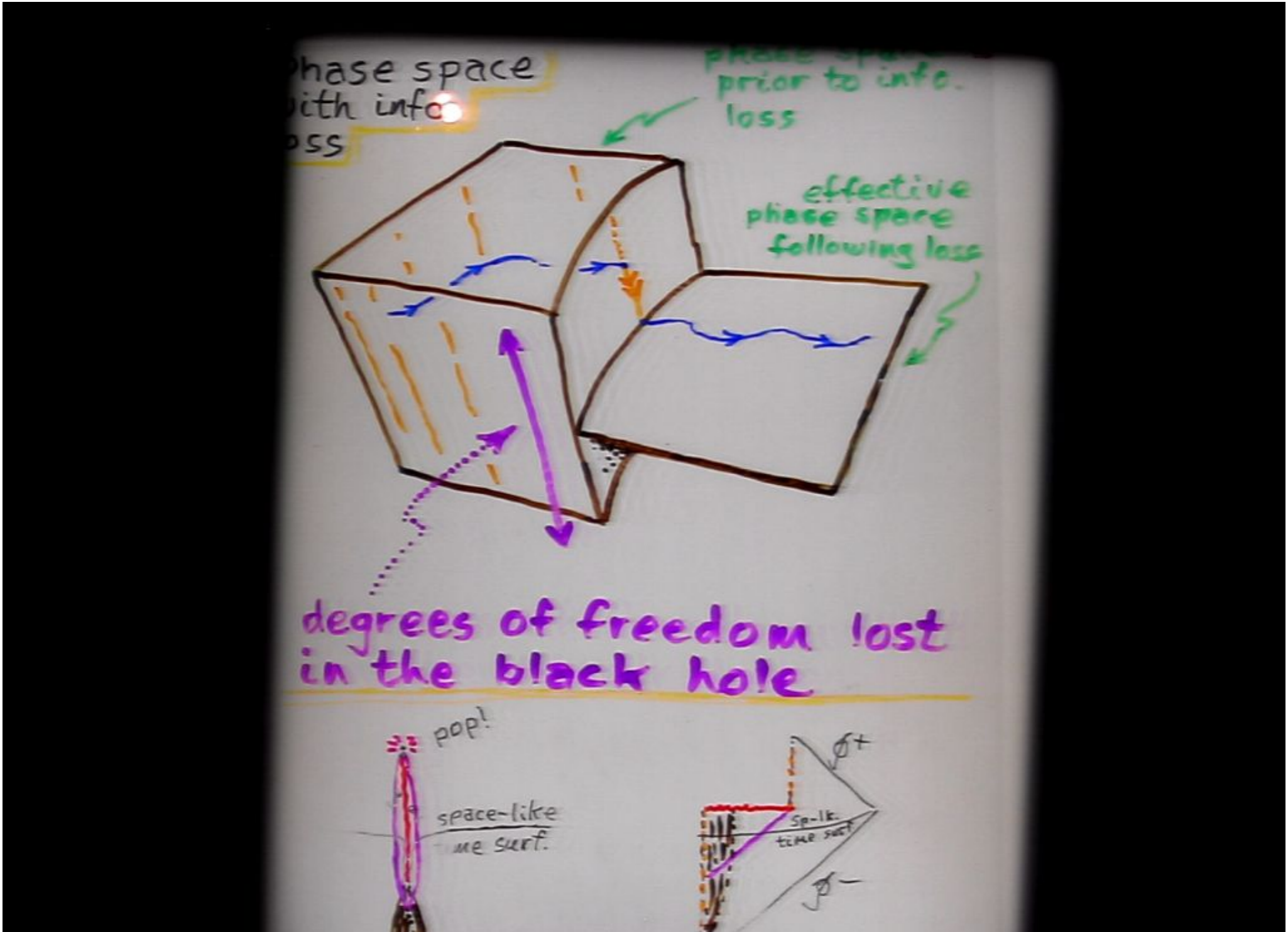
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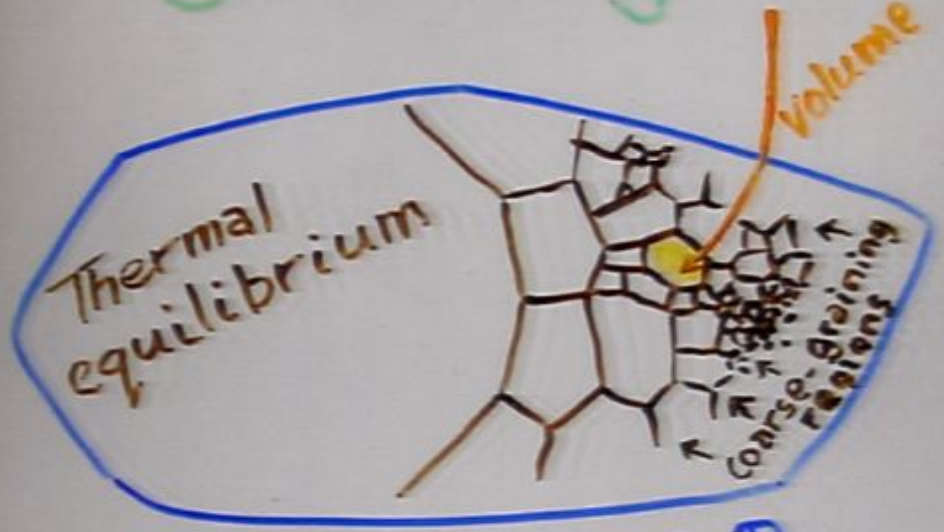
$S = k \log V$

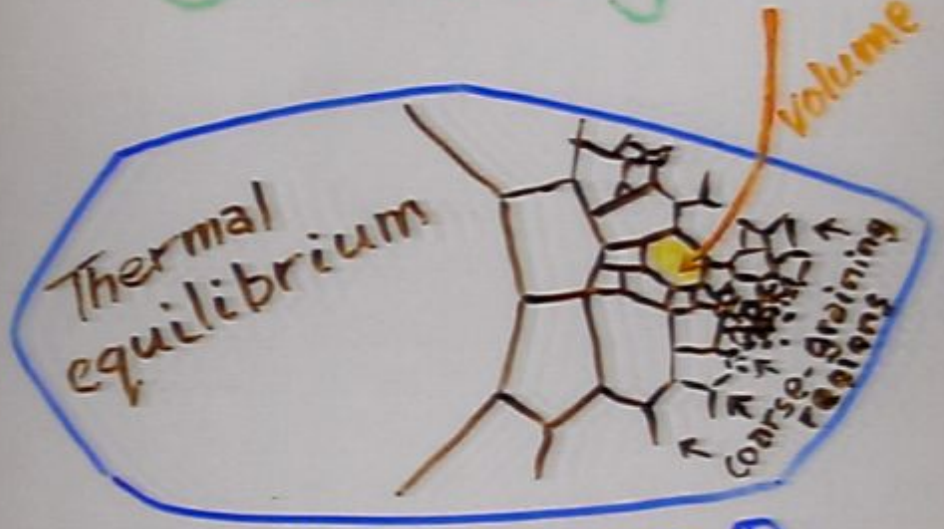


Note: $\log(VW) = \log V + \log W$

So entropy is additive for independent systems

# of ENTROPY

$$S = k \log V$$



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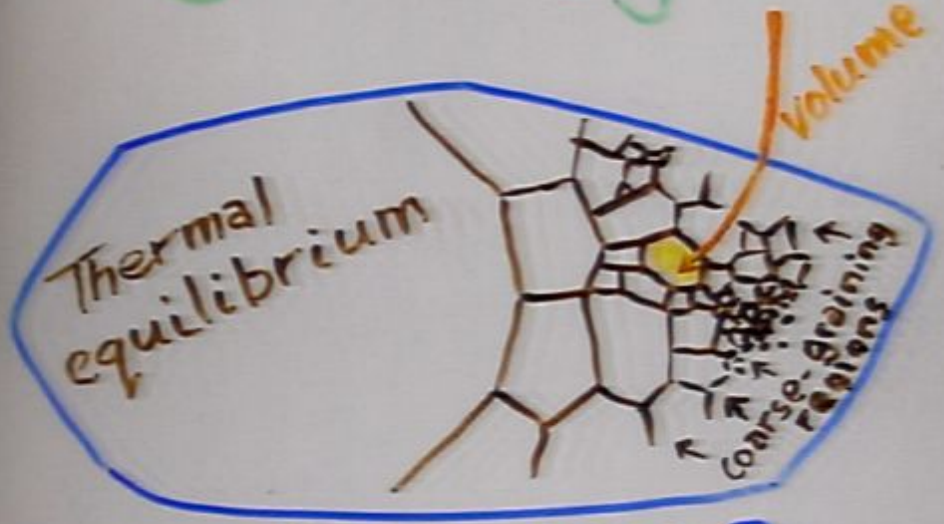

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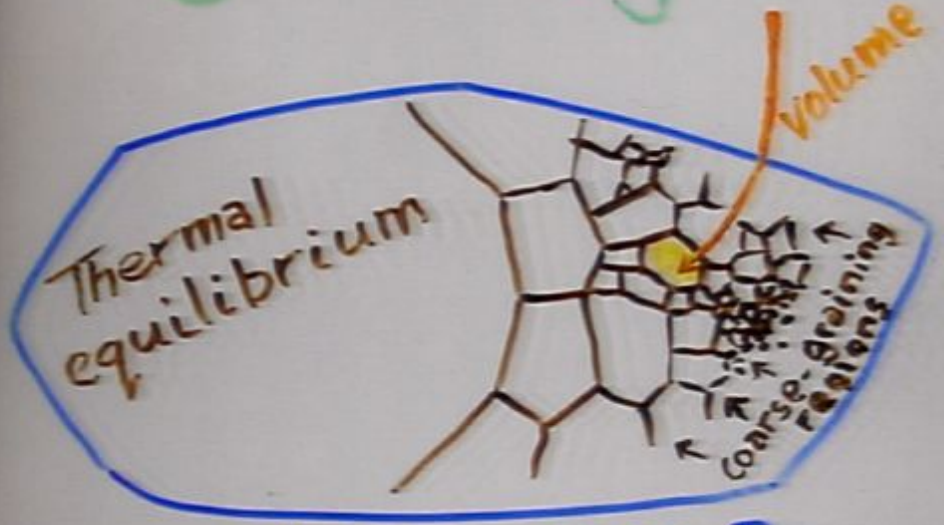

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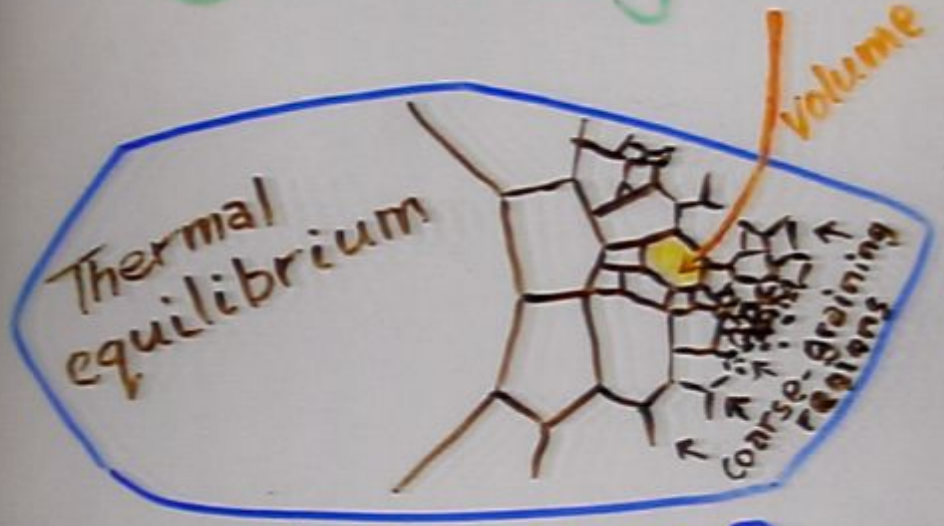

phase space $\mathcal{P}$

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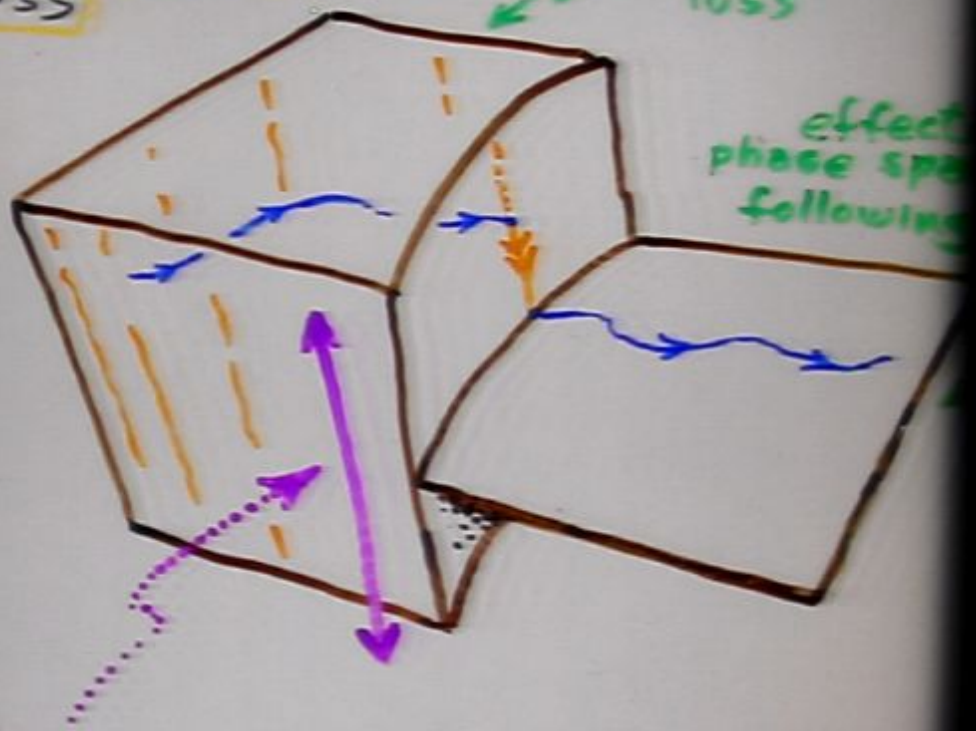
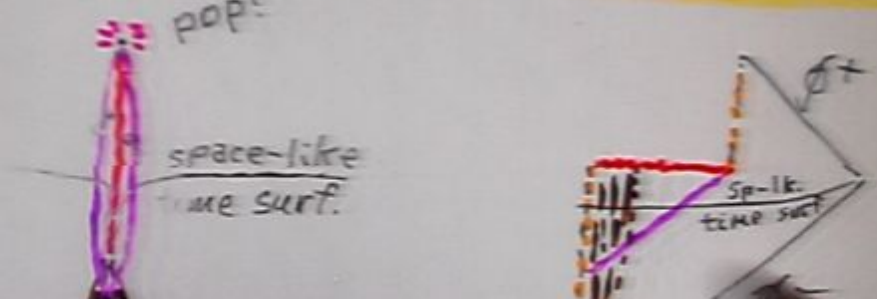
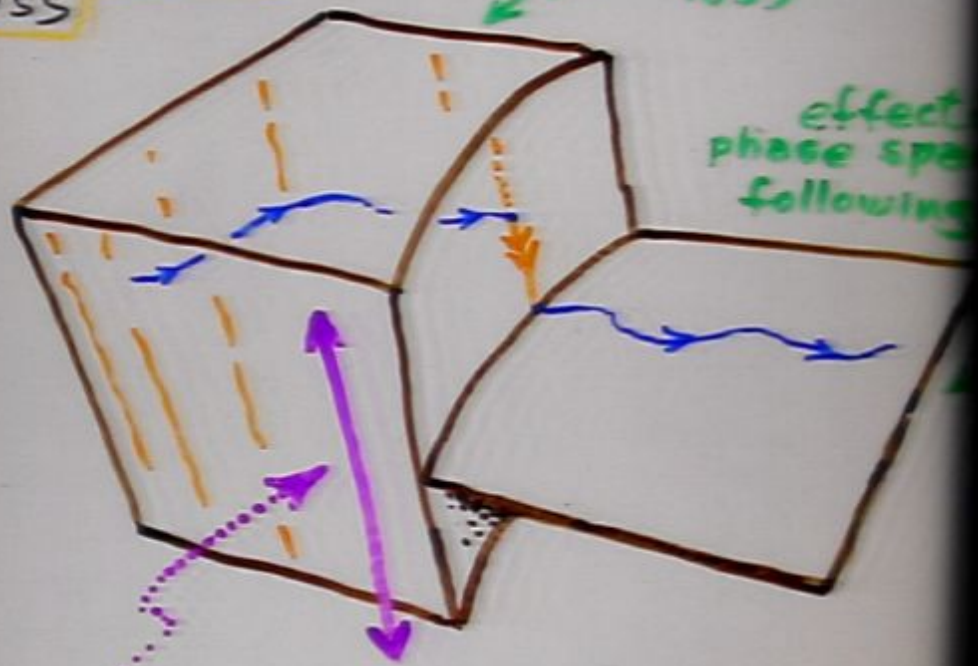
Phase space with info. loss



degrees of freedom lost in the black hole



Phase space with info. loss



degrees of freedom los
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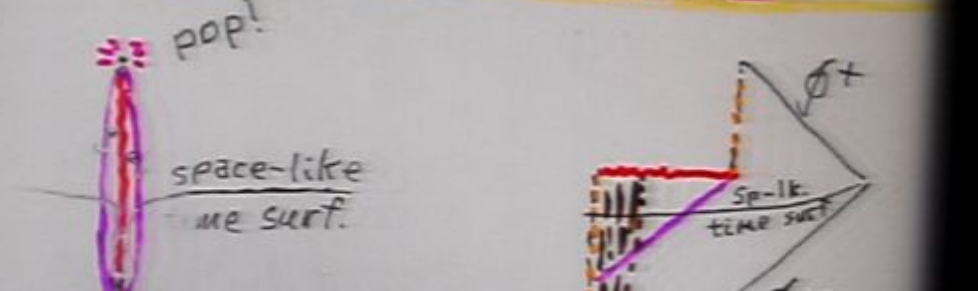
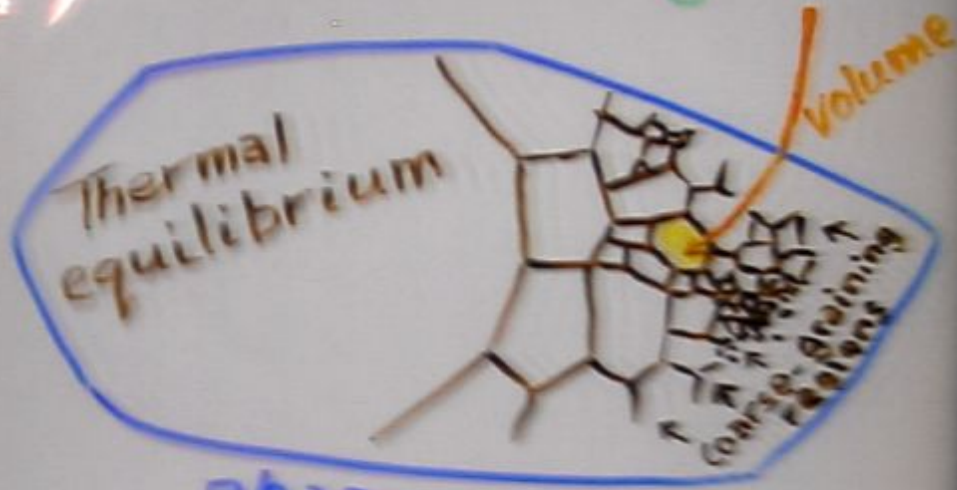


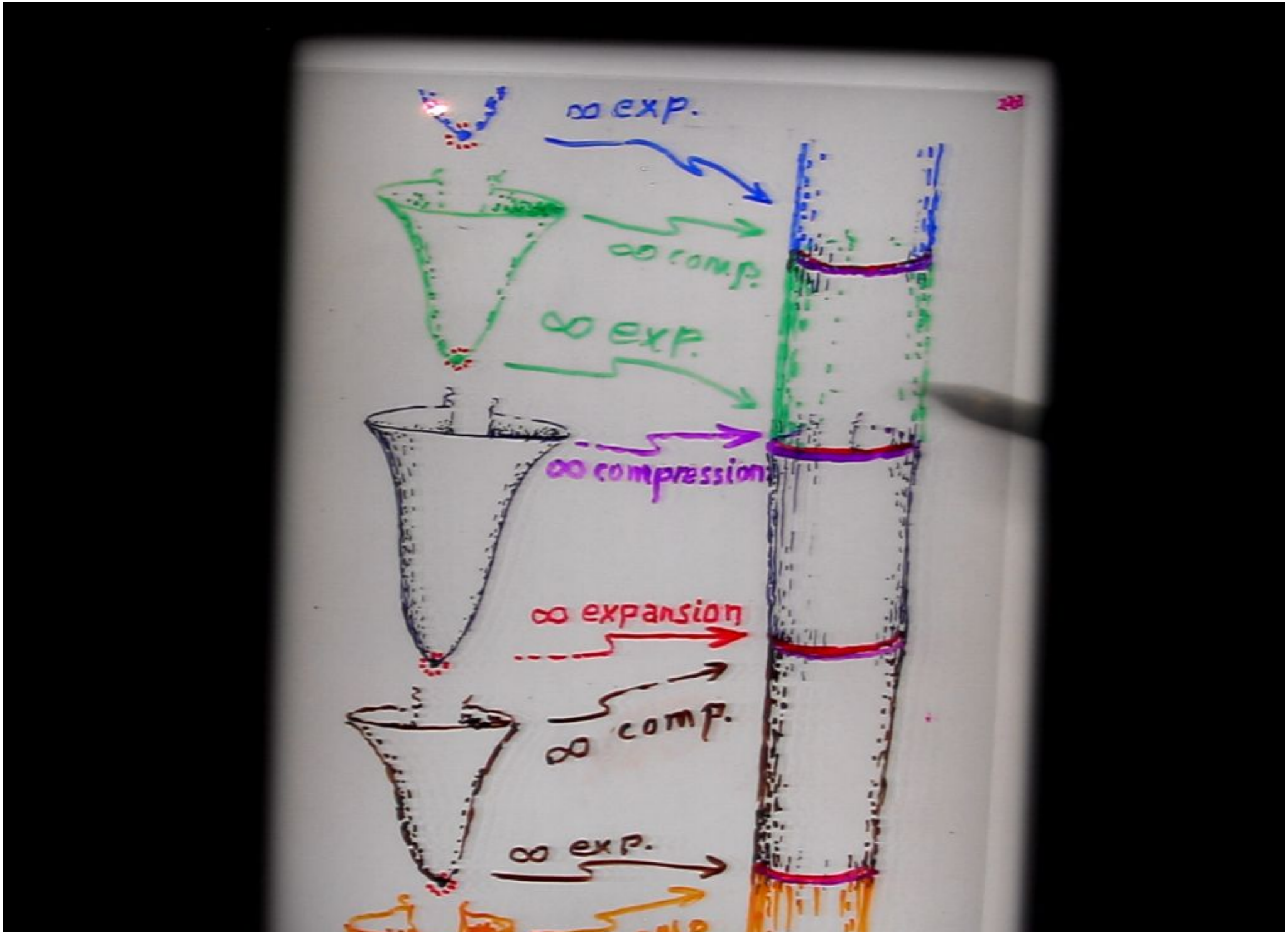
$S = k \log V$



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

So entropy is additive for independent systems

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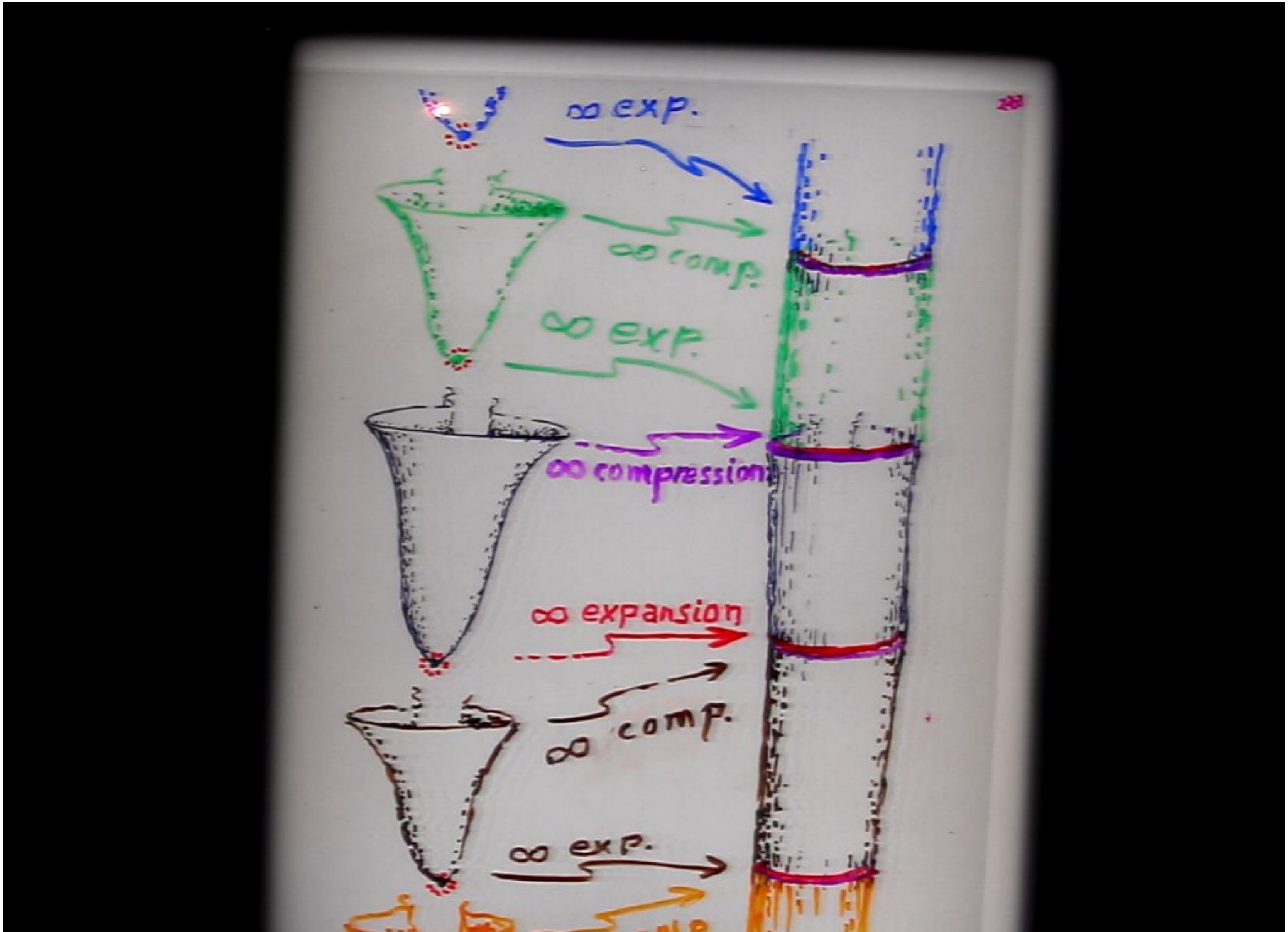
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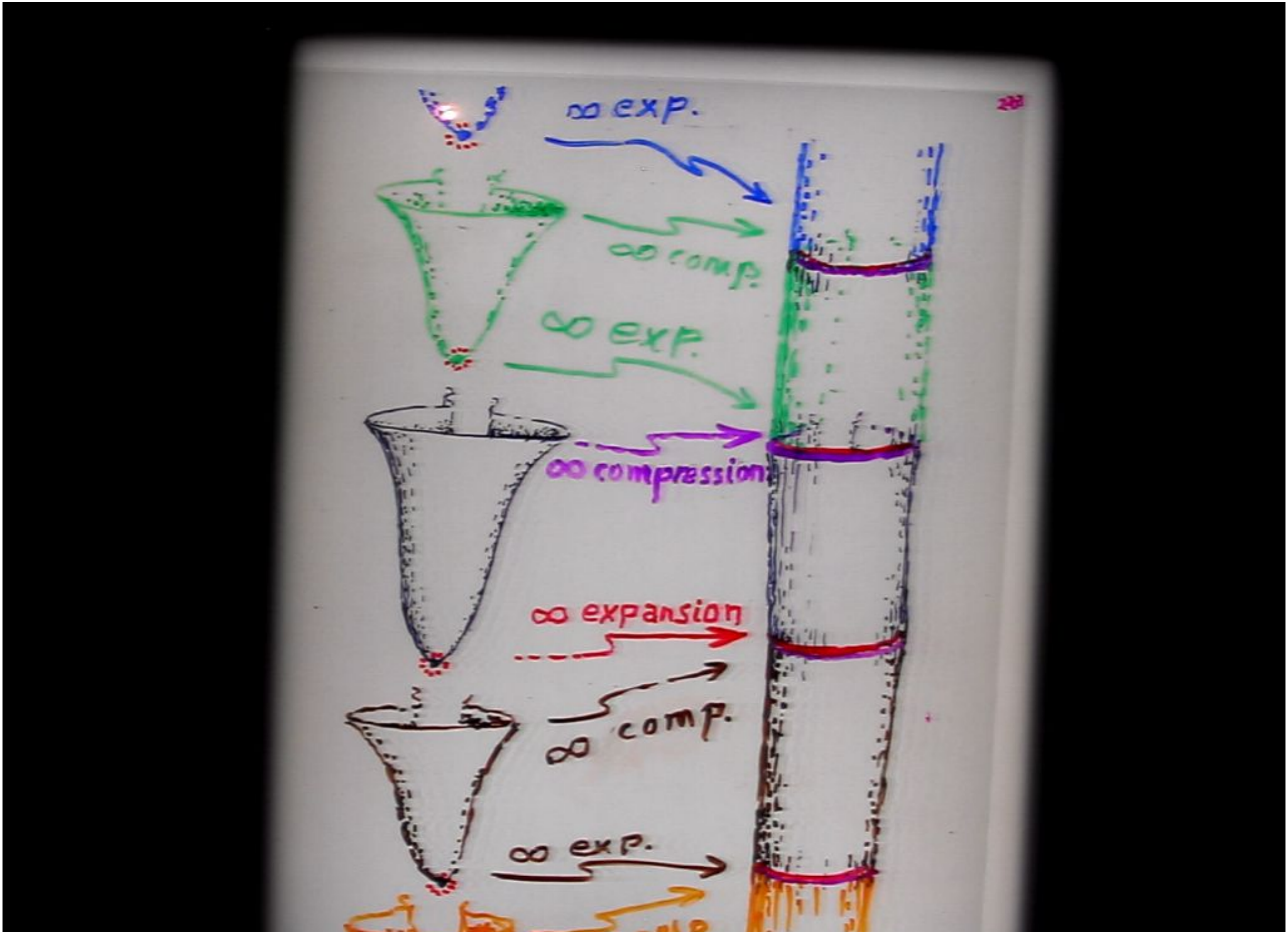
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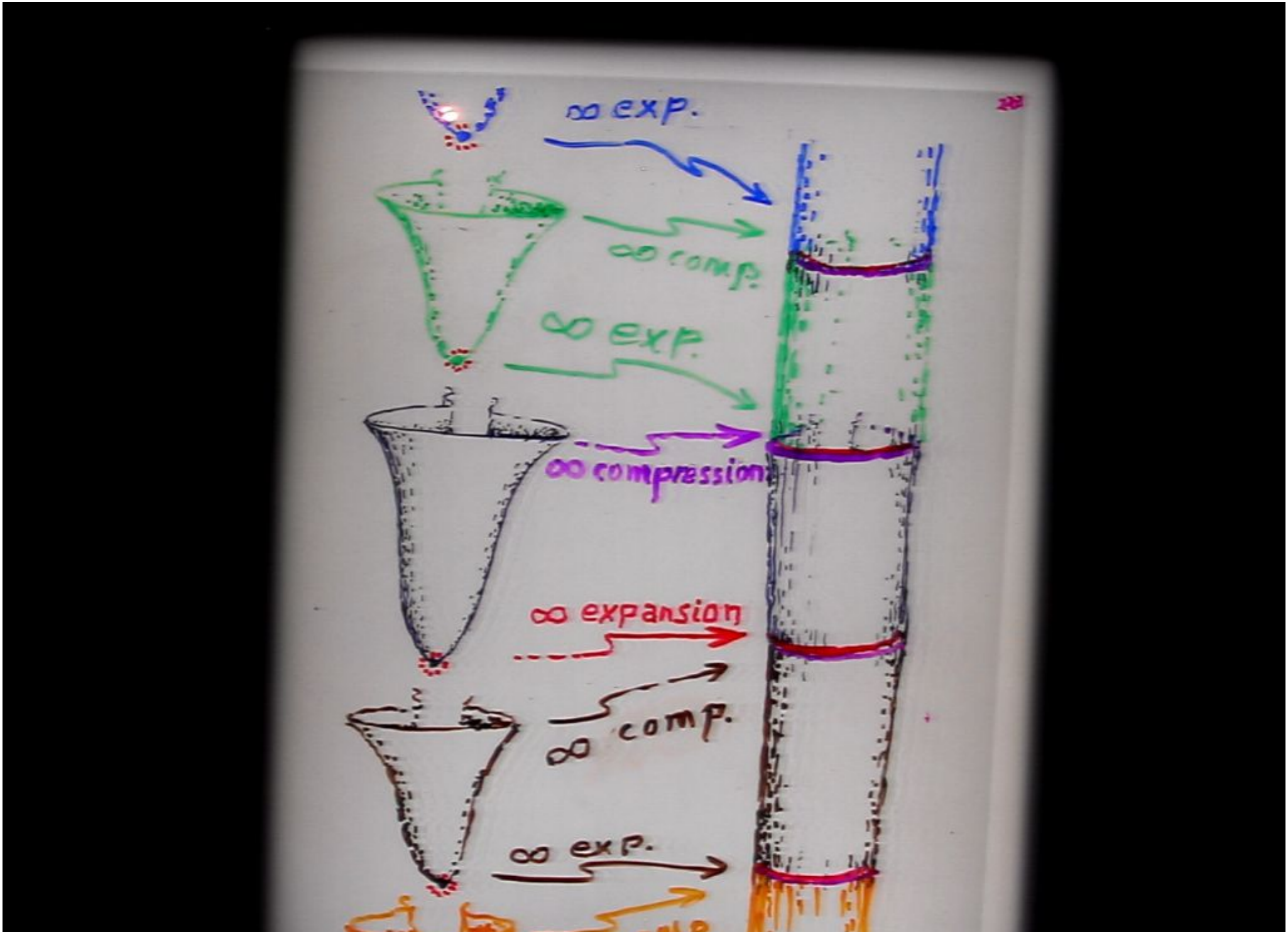
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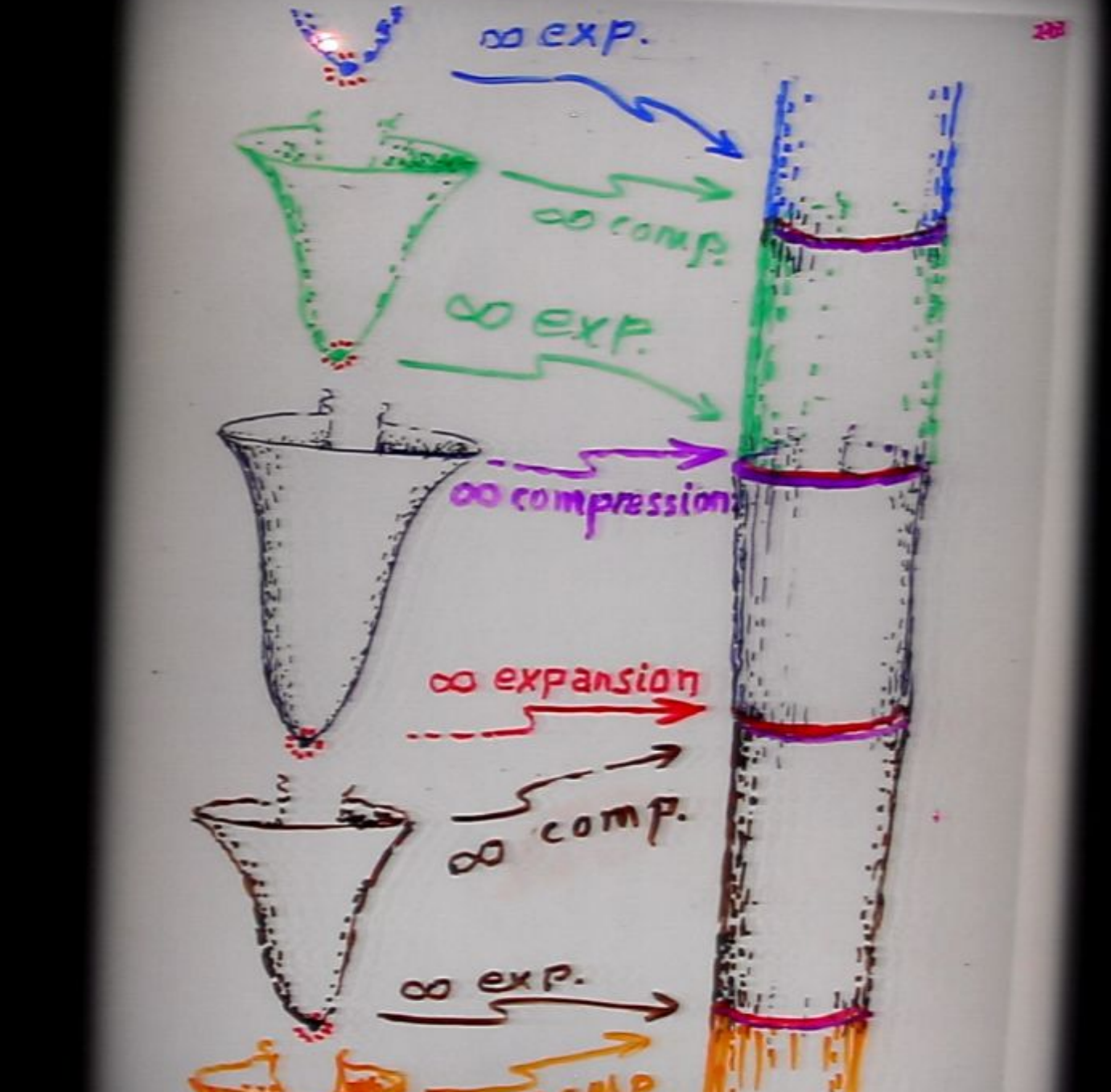
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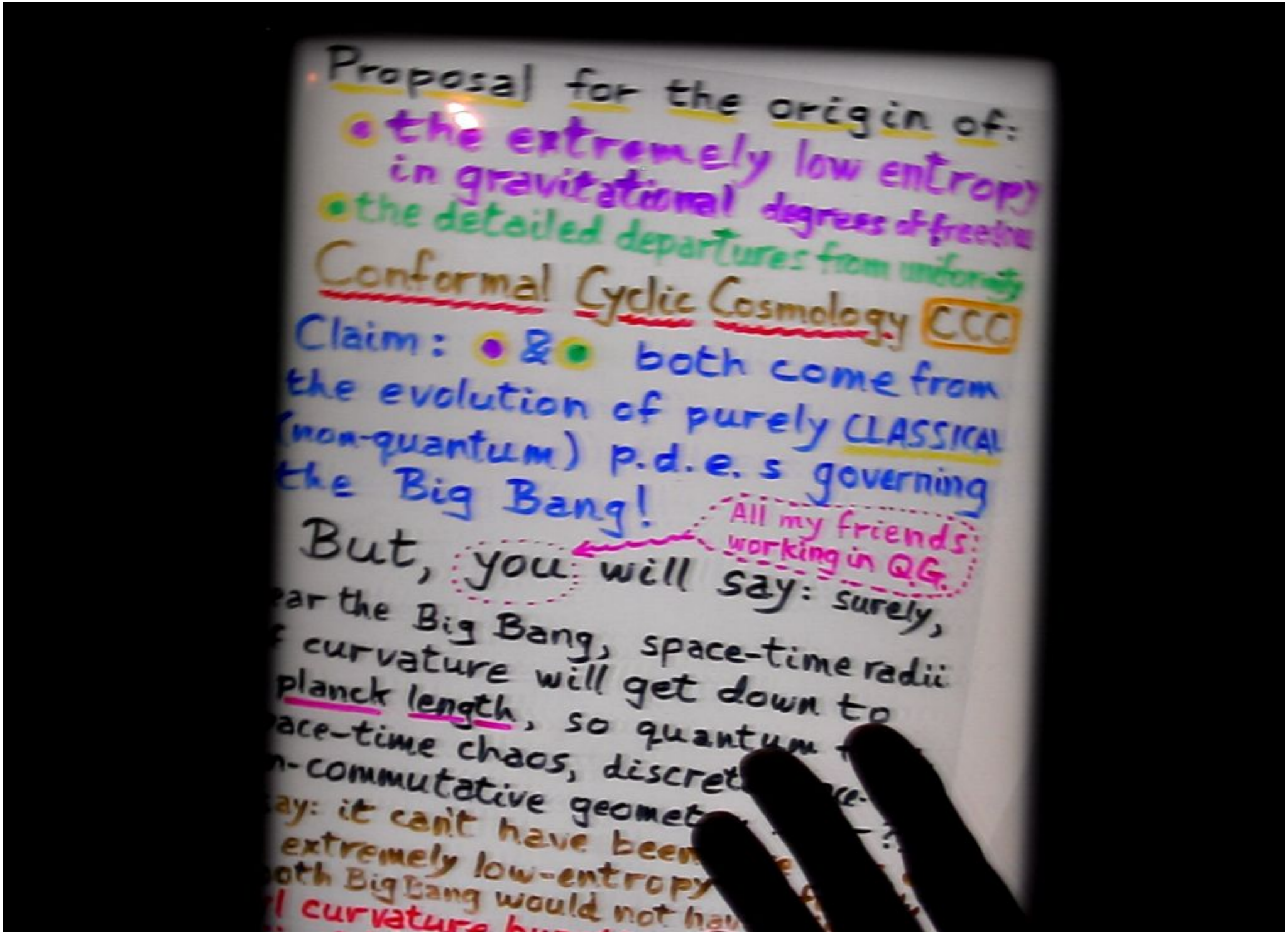
Proposal for the origin of:
• the extremely low entropy in gravitational degrees of freedom
• the detailed departures from uniformity
Conformal Cyclic Cosmology CCC
Claim: • & • both come from the evolution of purely CLASSICAL (non-quantum) p.d.e.s governing the Big Bang!
But, you will say: surely,
All my friends working in QG
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curvature will get down to
planck length, so quantum
ace-time chaos, discret
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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

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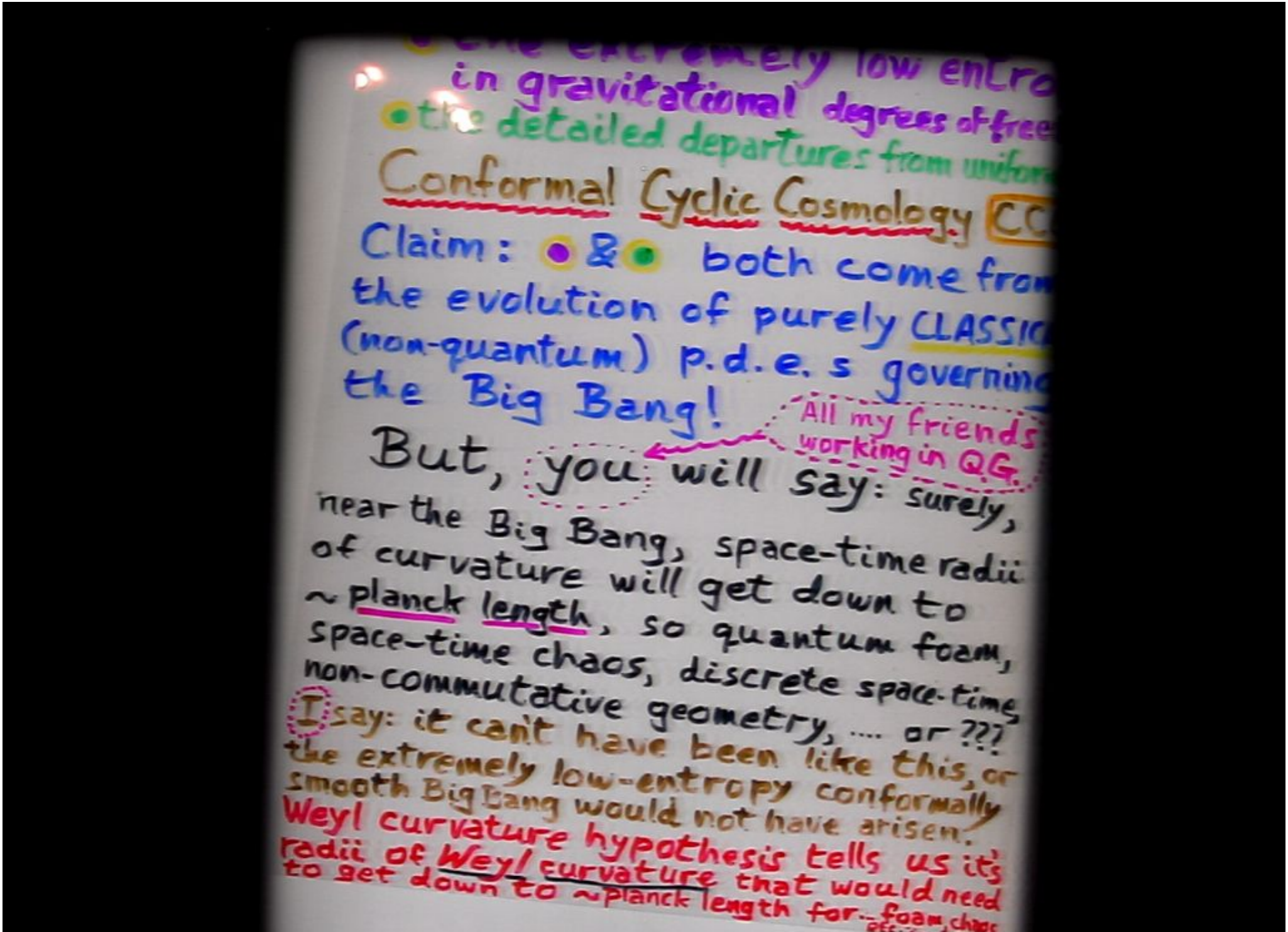

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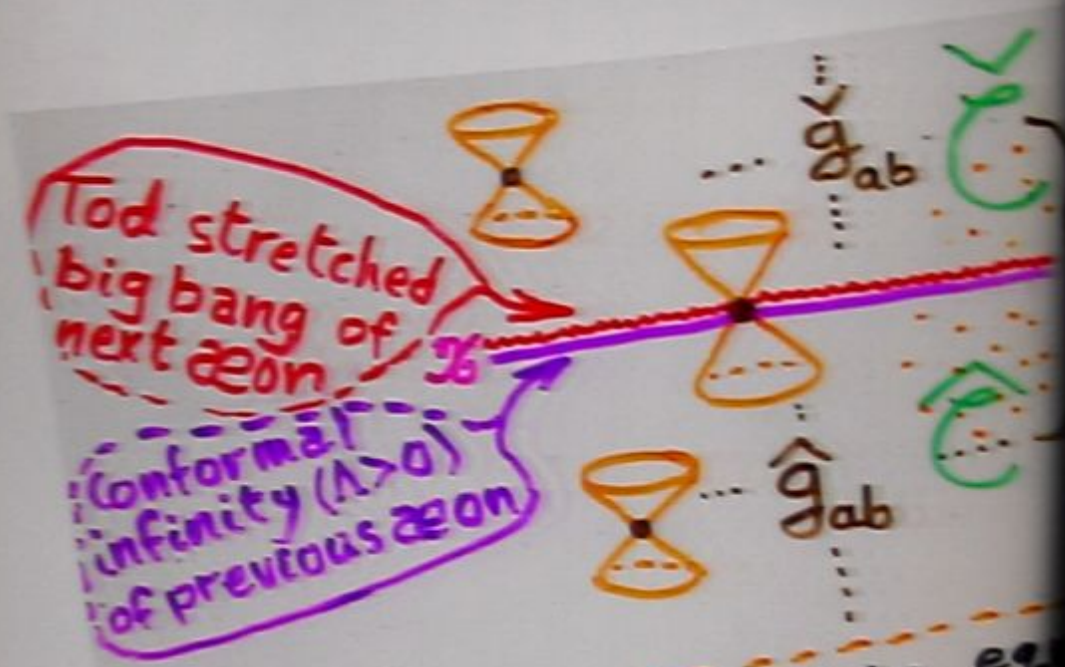


$\hat{g}_{ab} = \Omega^2 g_{ab}$

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

At $\mathscr{J}$, $\Omega \to \infty$, $\omega \to 0$ (ω smooth across

Einstein eq

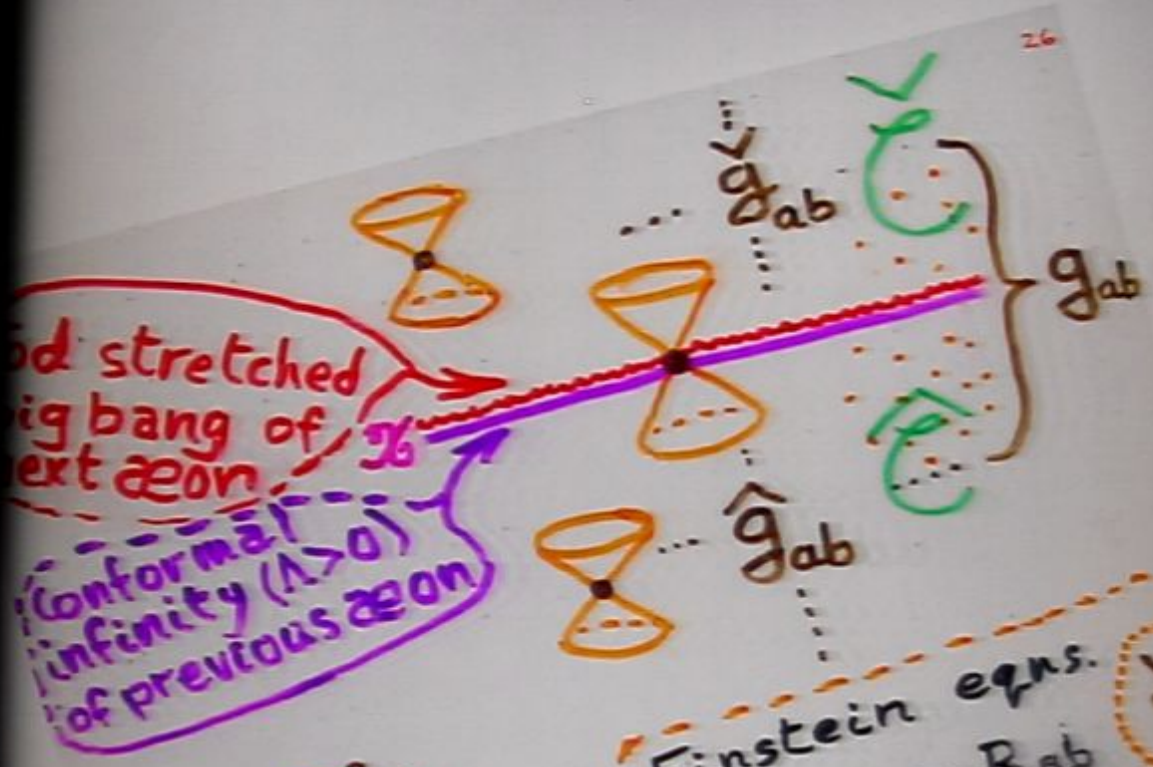
$E_{ab} = \frac{1}{2} R g_{ab} - R$

$= 8\pi G T_{ab}$

In $\hat{\mathscr{C}}$, we assume that

has died away (CCC

ie. $\hat{R}$



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...ext æon

(conformal infinity ($\Lambda>0$) of previous æon)

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

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

At $\mathscr{I}$, $\Omega \to \infty$, $\omega \to 0$ (ω smooth across $\mathscr{I}$)

Einstein eqns. ($\Lambda > 0$)

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

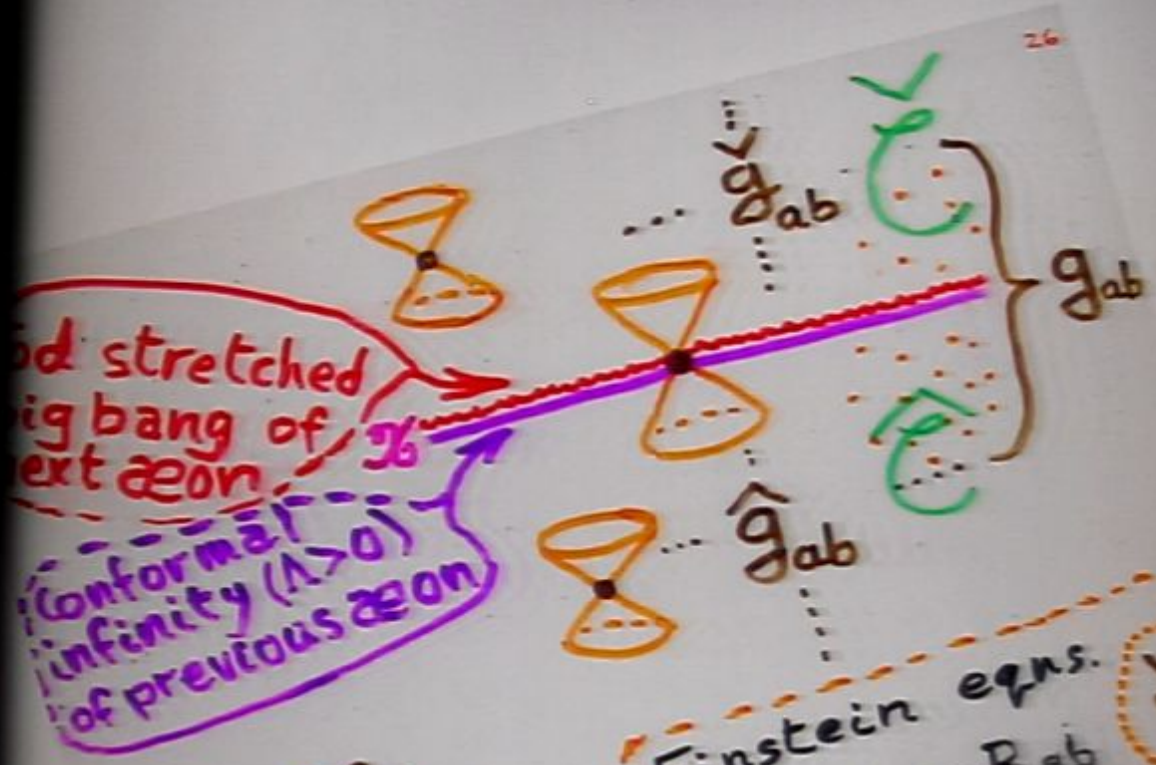
$= 8\pi G T_{ab} + \Lambda g$

In $\hat{\mathscr{E}}$, we assume that all ...

mass has died away (CCC hyp...

$\hat{\nabla}^a \hat{T}_a = 0$, i.e. $\hat{R} = 4\Lambda$

...t T_a ... at the ...



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

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

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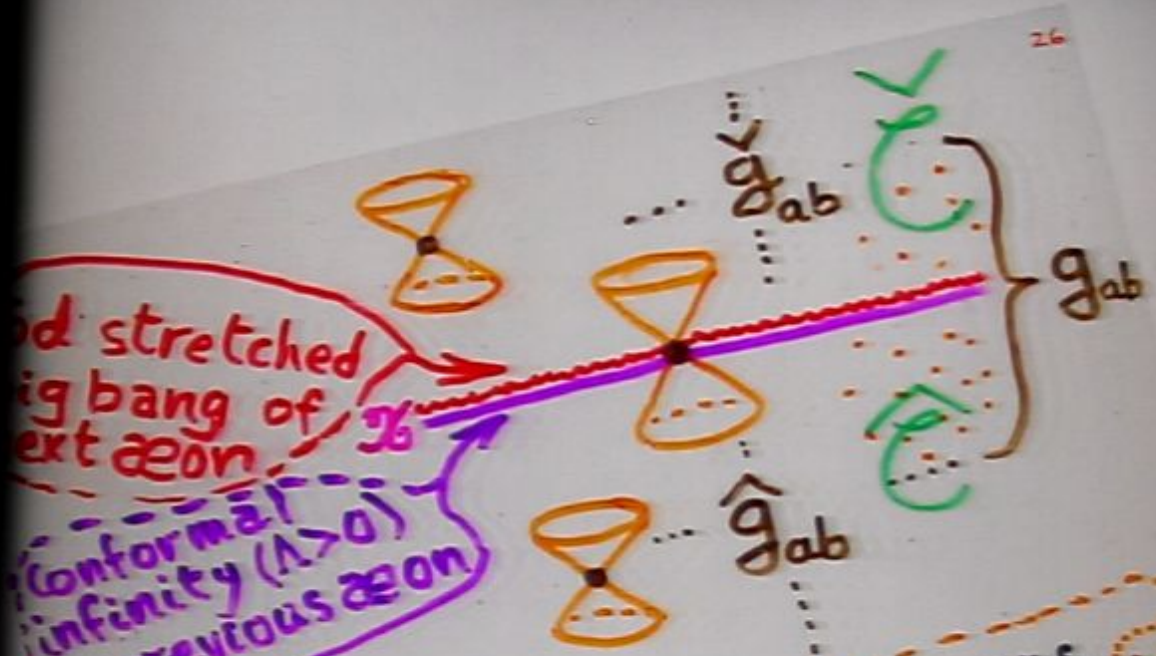
T_a at the



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

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

Einstein eqns. ($\check{V}$ or Λ)

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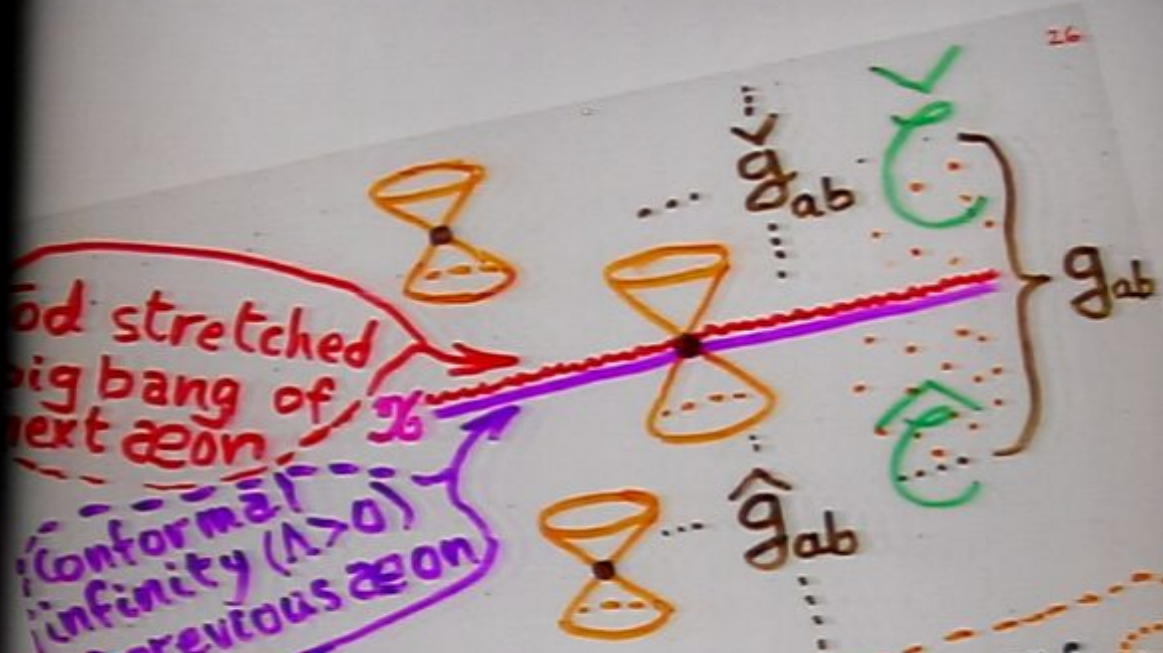

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At $\mathscr{I}$, $\Omega \to 0$, $\omega \to 0$ (ω smooth across $\mathscr{I}$)

Einstein eqns. (Λ or $\check{\Lambda}$)

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that $\hat{T}^a_a = 0$, i.e. $\hat{R} = 4\Lambda$

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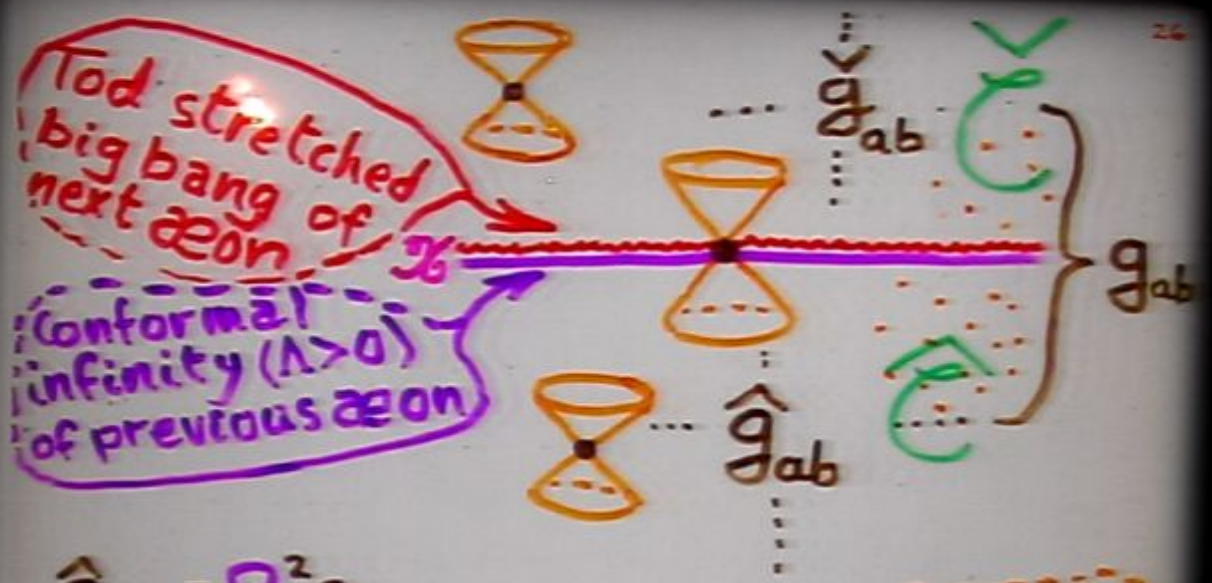

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At $\mathscr{I}$, $\Omega \to \infty$
$\omega \to 0$ (ω smooth across $\mathscr{I}$)

Einstein eqns. ($\check{}$ or $\hat{}$)

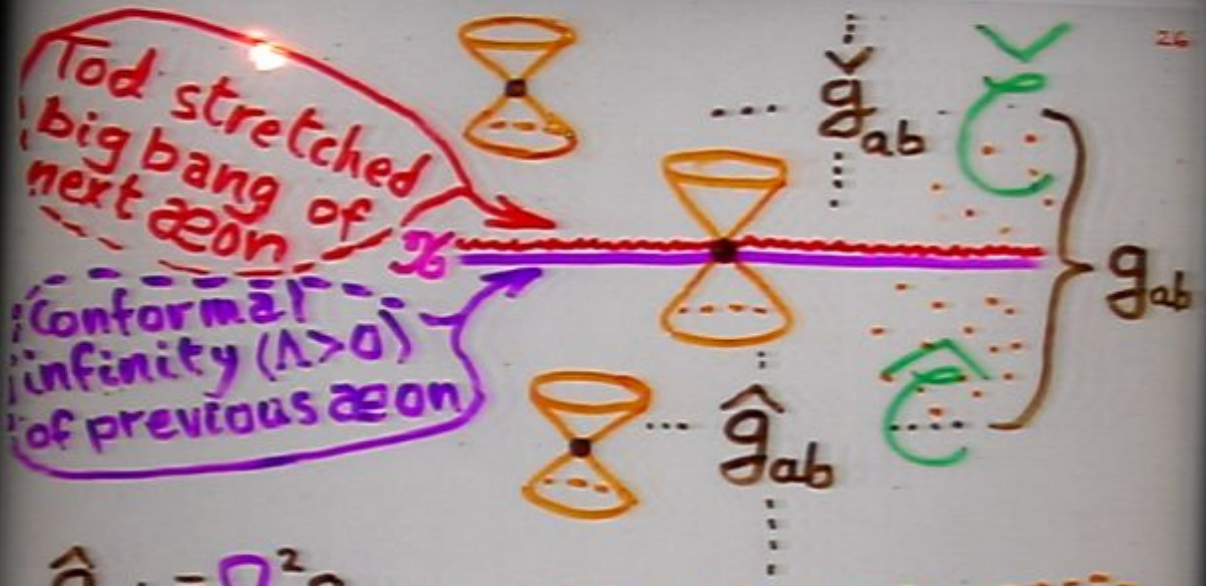
$E_{ab} = \frac{1}{2} R g_{ab} - R_{ab}$
$= 8\pi G T_{ab} + \Lambda g_{ab}$

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

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

Preserves ($\check{}$ or $\hat{}$)



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At $\mathscr{I}$, $\Omega \to \infty$, $\omega \to 0$ (ω smooth across $\mathscr{I}$)

Einstein eqns. (V or Λ)

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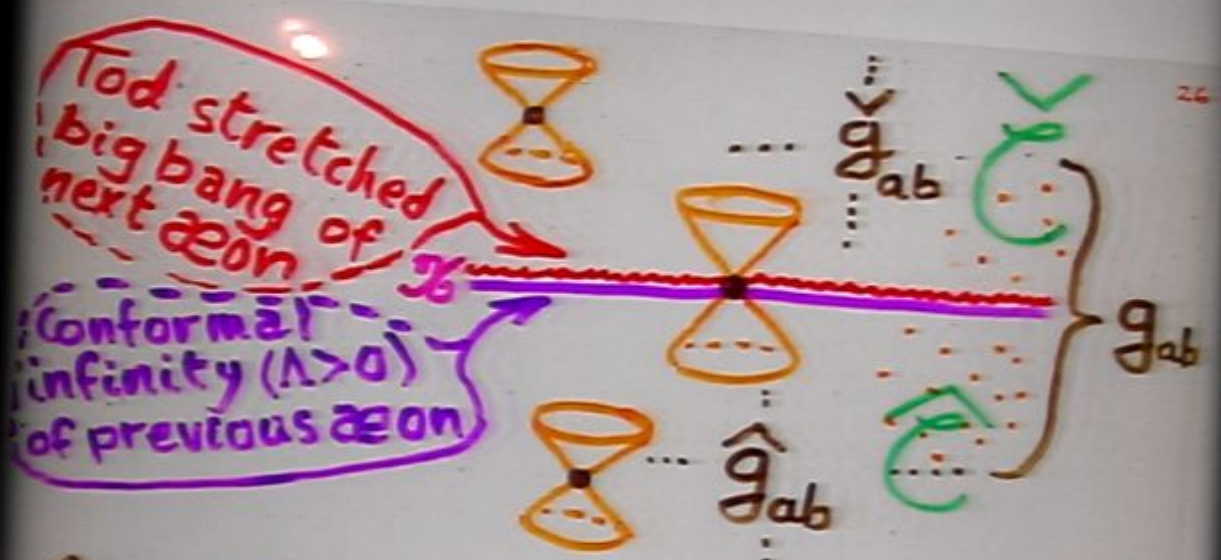

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Einstein eqns.

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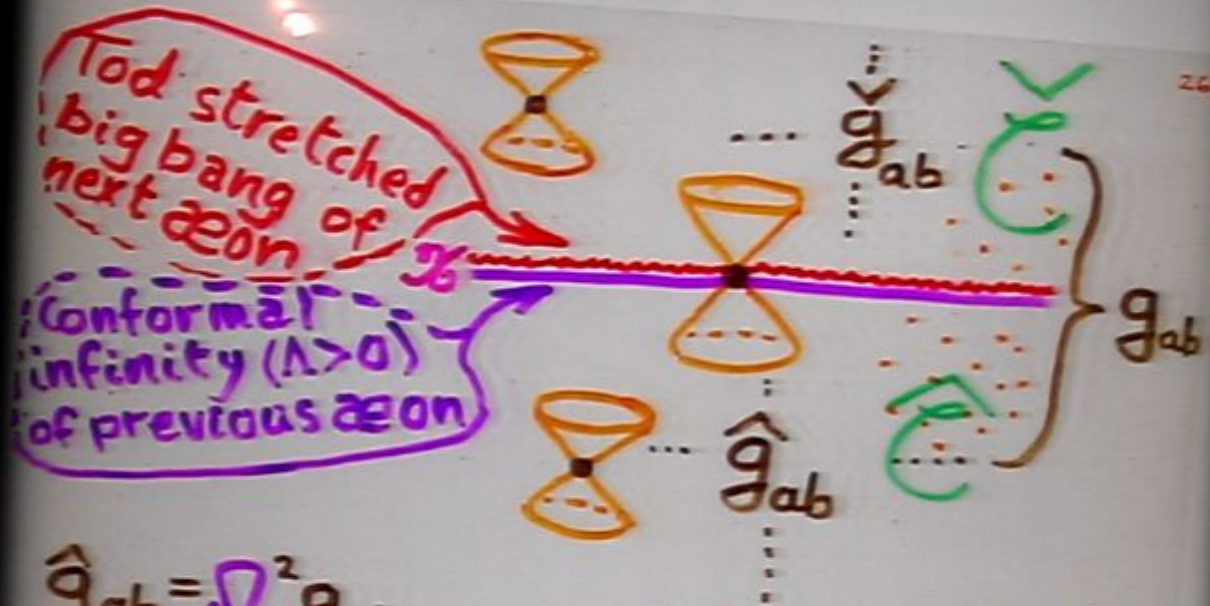

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$\omega \to 0$ (ω smooth across $\mathscr{X}$)

Einstein eqns.

$E_{ab} = \frac{1}{2} R g_{ab} - R_{ab}$ ($\vee$ or $\wedge$)

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

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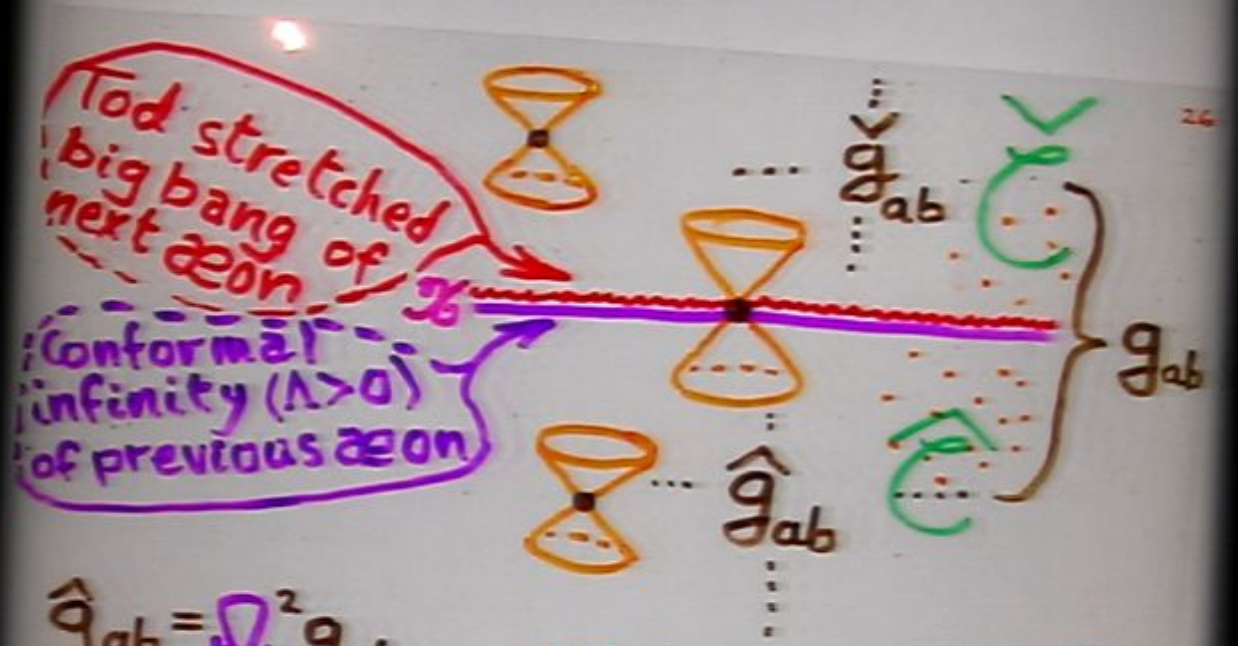

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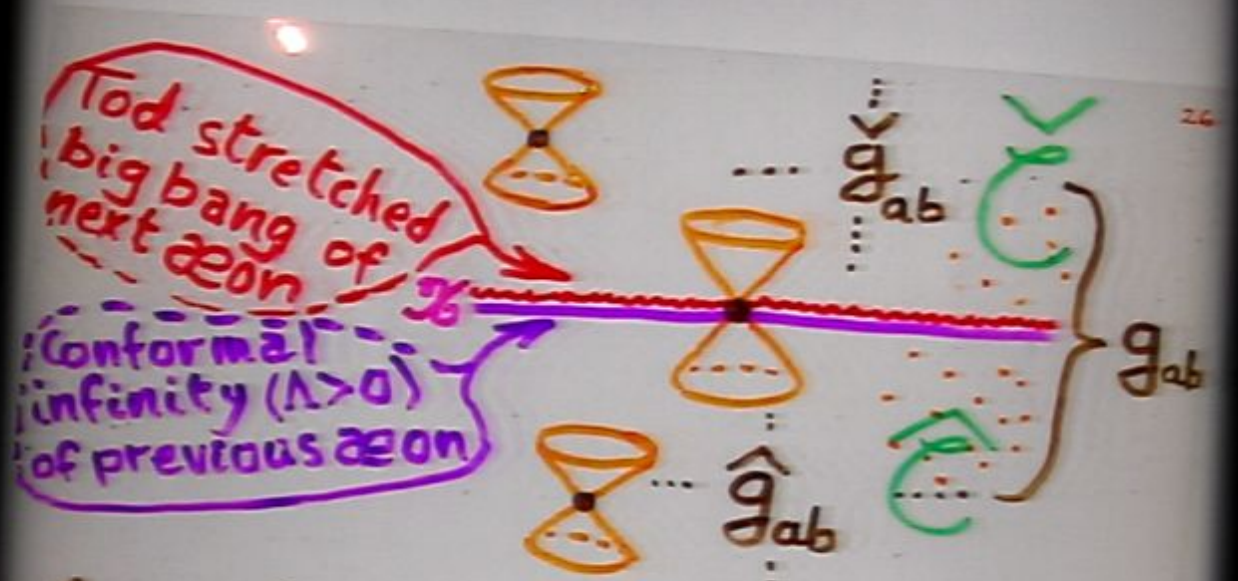

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At $\mathscr{I}$, $\Omega \to 0$

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Einstein eqns.

$E_{ab} = \frac{1}{2} R g_{ab} - R_{ab}$ (or $\check{\Lambda}$)

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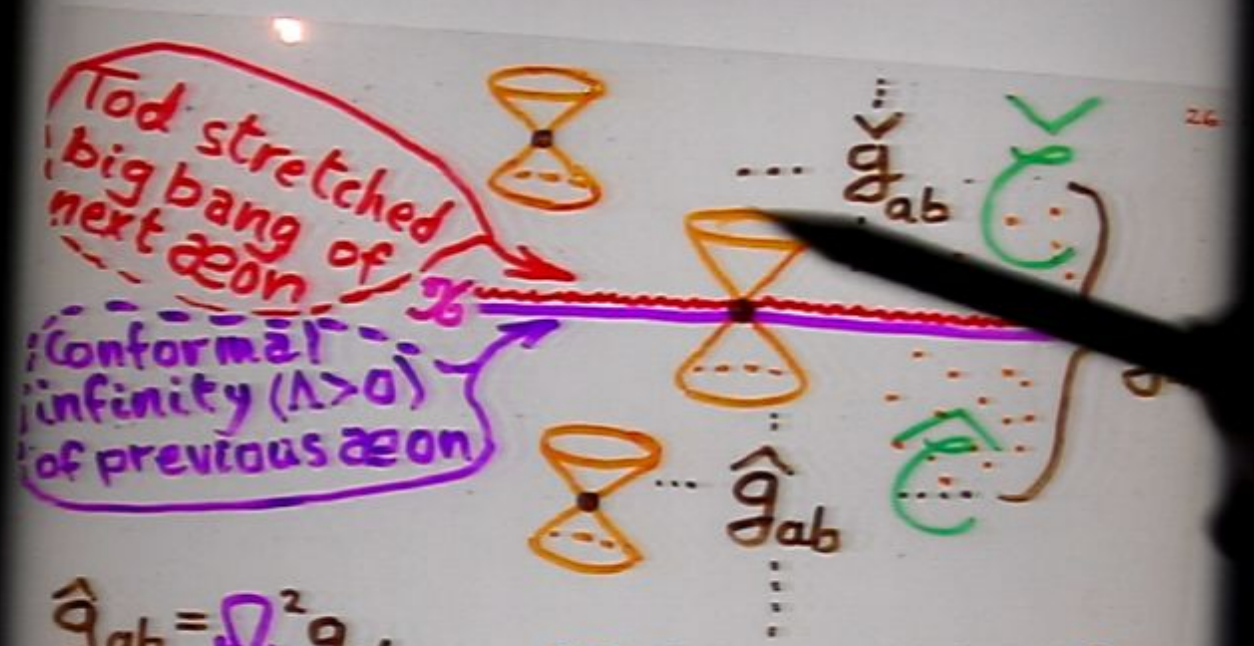

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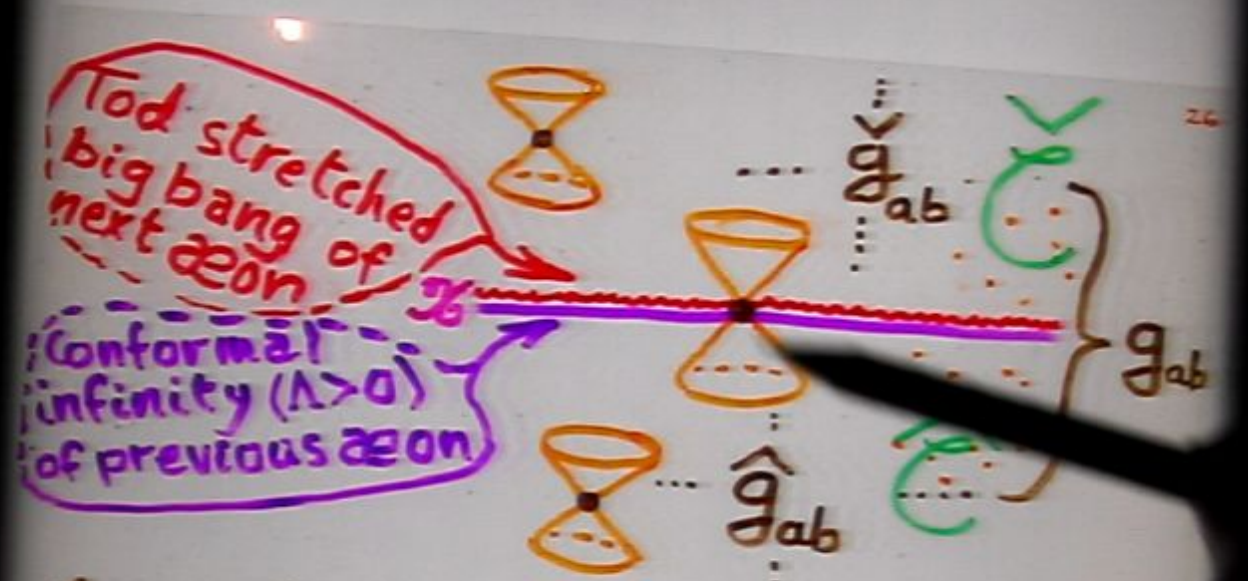


$\hat{g}_{ab} = \Omega^2 g_{ab}$

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

At $\mathscr{I}$, $\Omega \to 0$

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

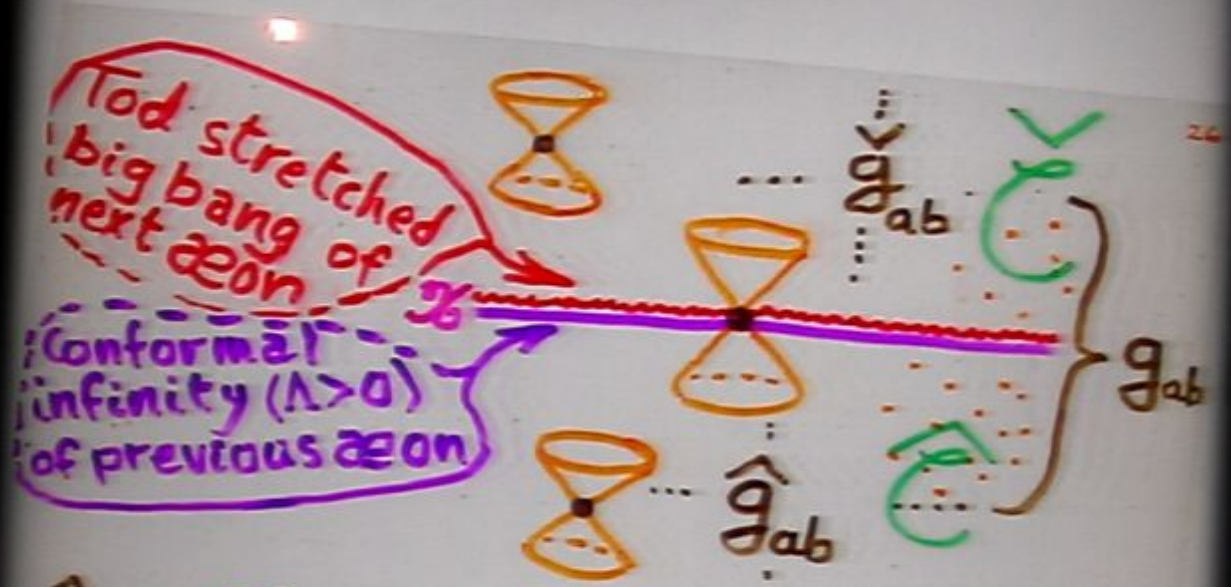
Einstein eqns.

$E_{ab} = \frac{1}{2} R g_{ab} - R_{ab}$ (or $\check{\Lambda}$)

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

In $\hat{\mathscr{E}}$, 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 $\hat{\mathscr{E}}$, $\check{\mathscr{E}}$, we find that the conf.



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

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

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

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

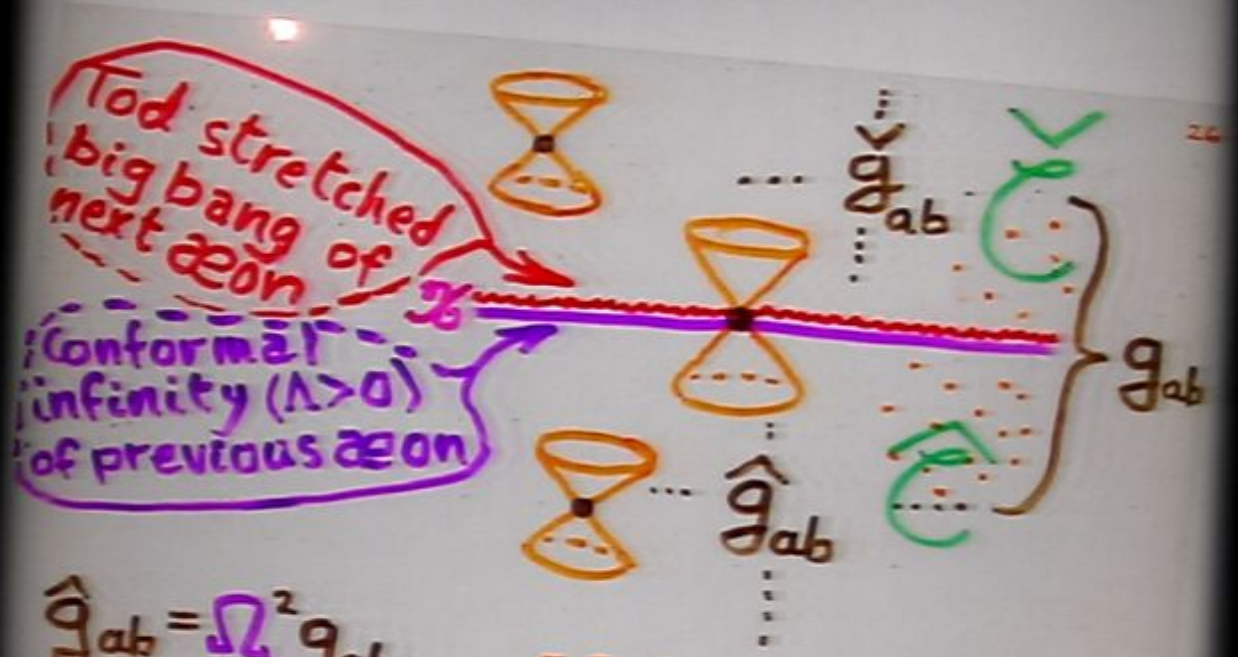
Einstein eqns.

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

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

In $\hat{\mathscr{E}}$, we assume that all rest-mass has died away (CCC hypothesis) so that $\hat{T}^a_a = 0$, ie. $\hat{R} = 4\Lambda$.

In $\hat{\mathscr{E}}$, $\overset{\vee}{\mathscr{E}}$, we find that the conf.



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

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

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

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

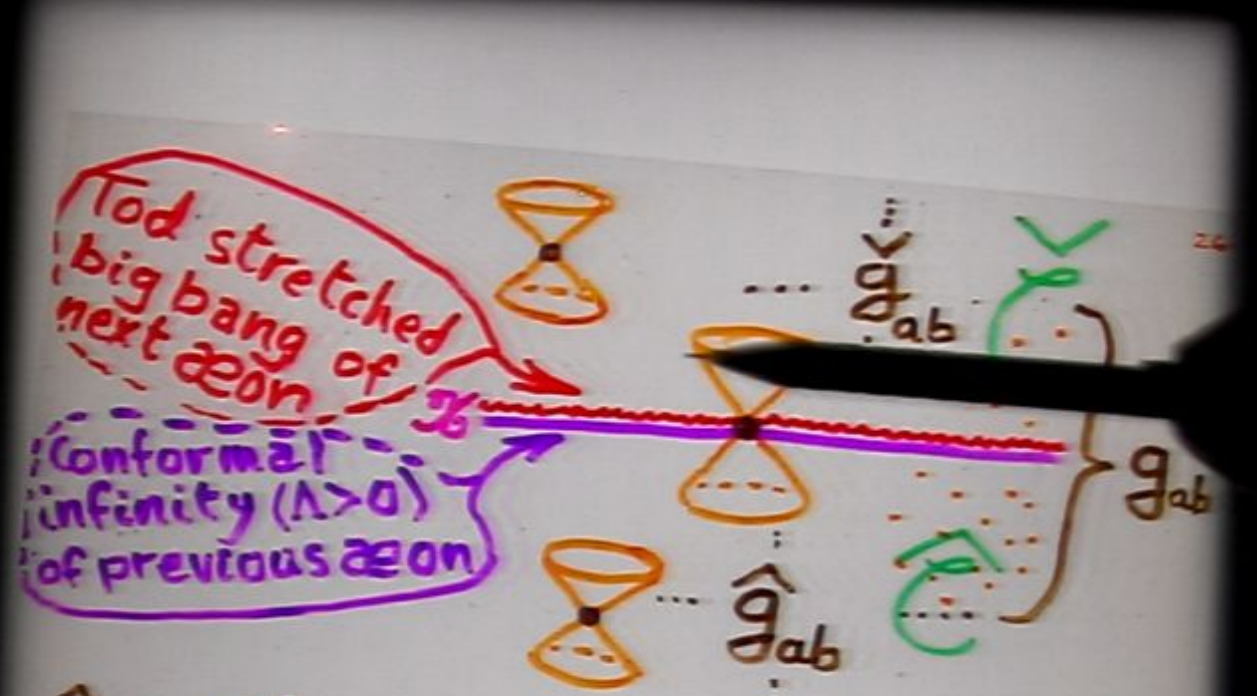
Einstein eqns.

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

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

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



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

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

At $\mathscr{I}$, $\Omega \to \infty$
$\omega \to 0$ (ω smooth across $\mathscr{I}$)

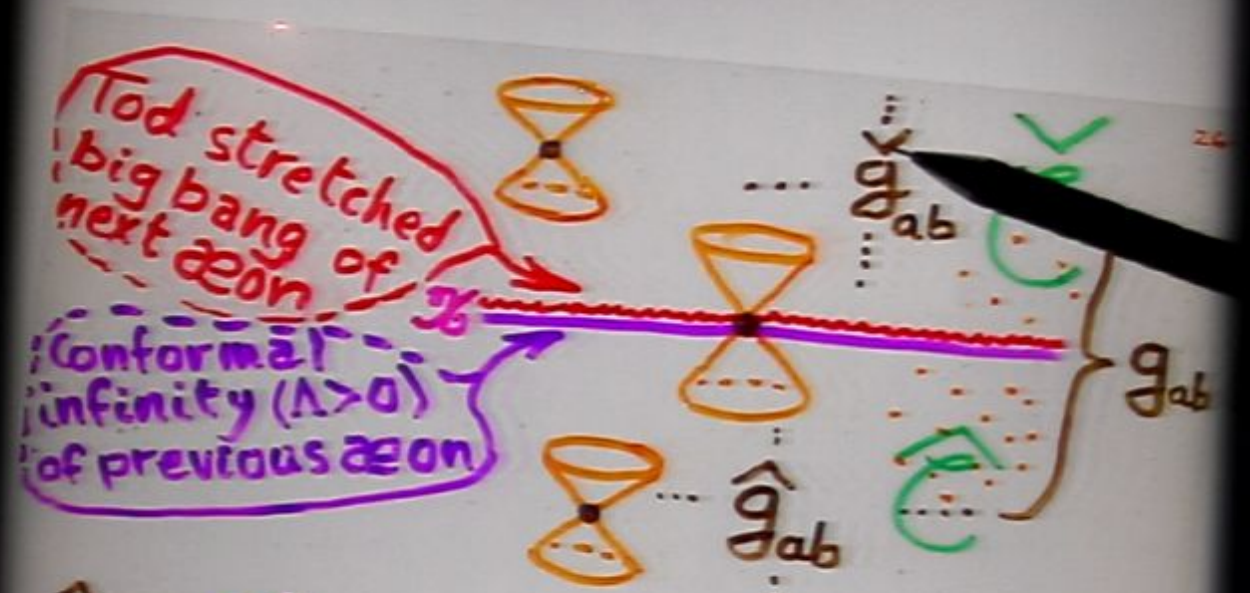
Einstein eqns.

$E_{ab} = \frac{1}{2} R g_{ab} - R_{ab}$ (V or Λ)

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

In $\hat{\mathscr{E}}$, 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 $\hat{\mathscr{E}}$, $\check{\mathscr{E}}$, we find th[illegible] the [illegible] of



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

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

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

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

Einstein eqns.

$E_{ab} = \frac{1}{2} R g_{ab} - R_{ab}$ (V or Λ)

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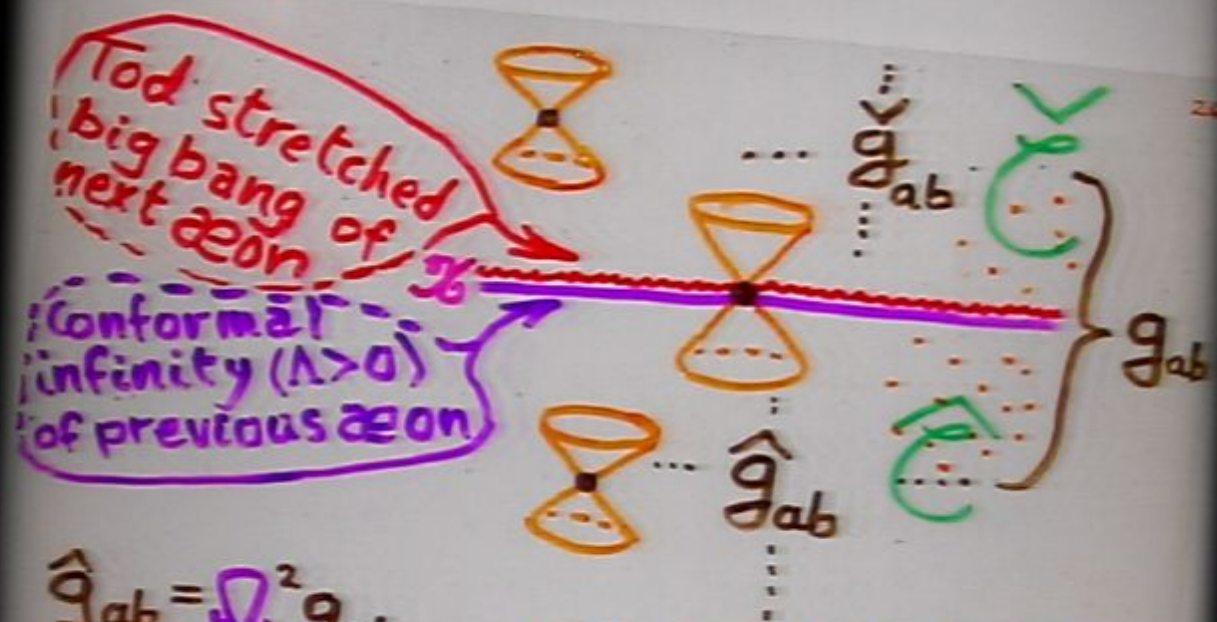
In $\hat{\mathscr{E}}$, we assume that all rest-mass has died away (CCC hypothesis) so that $\hat{T}^a_a = 0$, i.e. $\hat{R} = 4\Lambda$.

In $\hat{\mathscr{E}}$, $\check{\mathscr{E}}$, we find th[illegible]



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

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

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

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

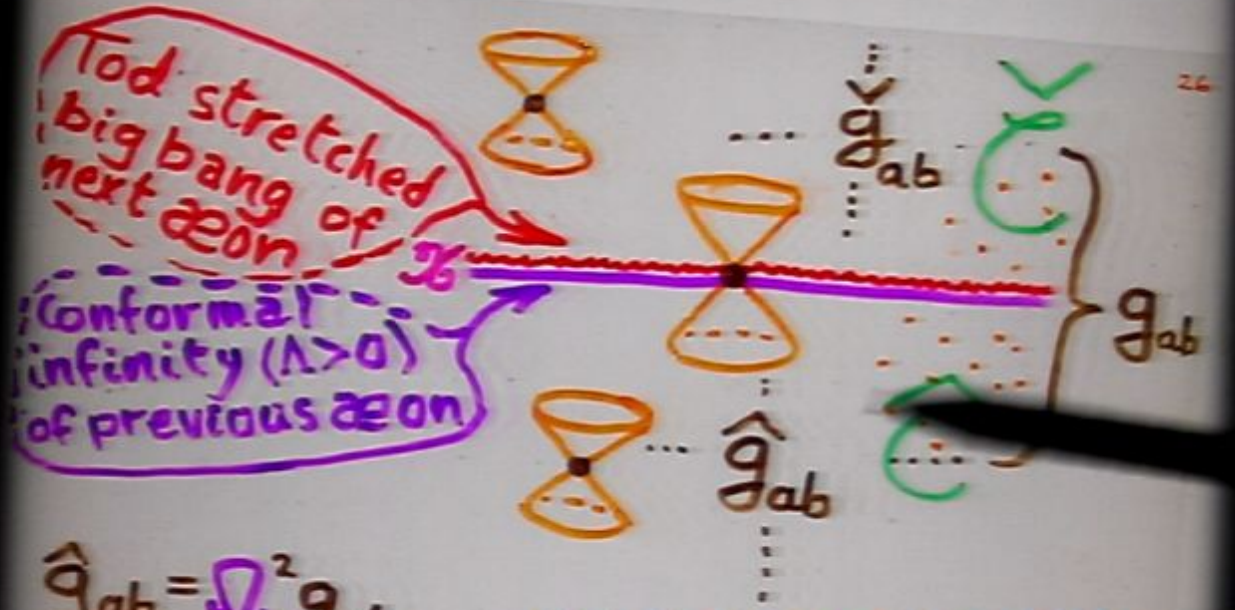
Einstein eqns.

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

$\vee$ or $\wedge$

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



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

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

At $\mathscr{I}$, $\Omega \to \infty$
$\omega \to 0$ (ω smooth across $\mathscr{I}$)

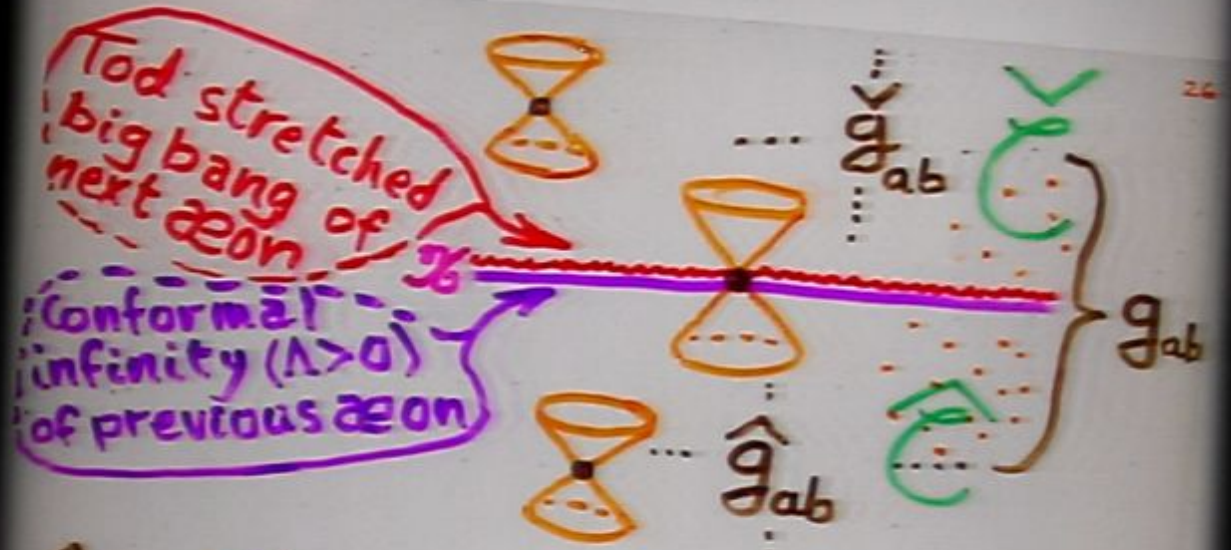
Einstein eqns.

$E_{ab} = \frac{1}{2} R g_{ab} - R_{ab}$ ($\check{V}$ or Λ)

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

In $\hat{\mathscr{E}}$, 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 $\hat{\mathscr{E}}$, $\check{\mathscr{E}}$ we fin[illegible] the conf[illegible]



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At $\mathscr{J}$, $\Omega \to 0$
$\omega \to 0$ (ω smooth across $\mathscr{J}$)

Einstein eqns.

$E_{ab} = \frac{1}{2} R g_{ab} - R_{ab}$ (or $\check{\Lambda}$)

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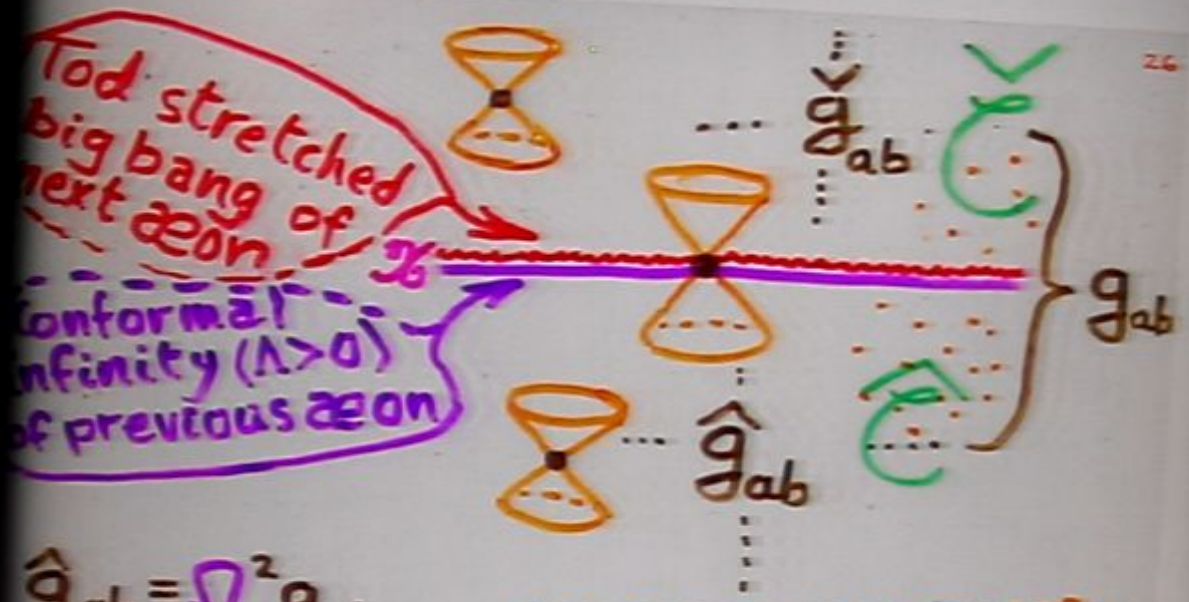
In $\hat{\mathscr{E}}$, $\check{\mathscr{E}}$, we find that the conf



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

Einstein eqns.

$E_{ab} = \frac{1}{2} R g_{ab} - R_{ab}$ (V or Λ)

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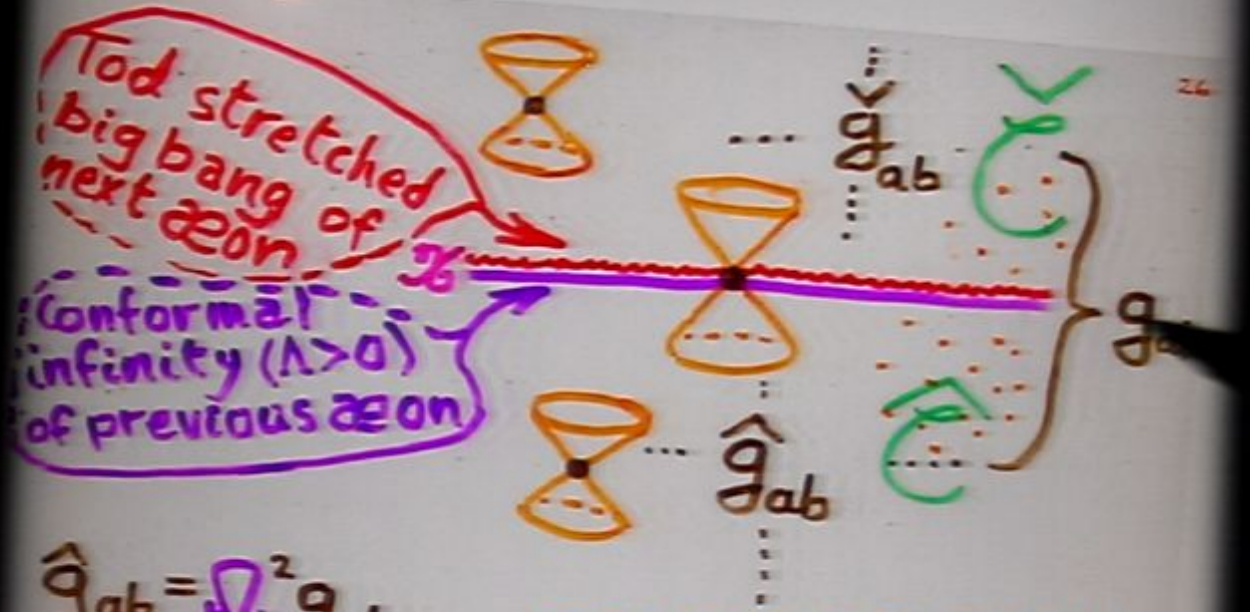
In $\hat{\mathscr{E}}$, $\check{\mathscr{E}}$, we find that the conf.



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

At $\mathscr{I}$, $\Omega \to \infty$
$\omega \to 0$ (ω smooth across $\mathscr{I}$)

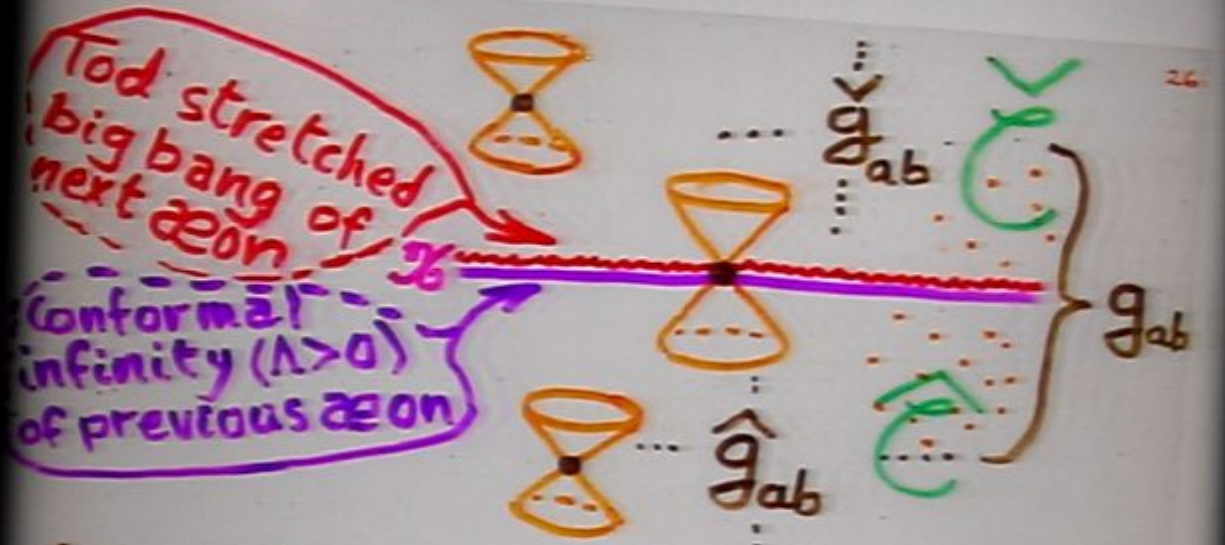
Einstein eqns.

$E_{ab} = \frac{1}{2} R g_{ab} - R_{ab}$ (or $\check{V}$ or Λ)

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

In $\hat{\mathscr{E}}$, 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 $\hat{\mathscr{E}}$, $\check{\mathscr{E}}$, we find that t[illegible] conf[illegible]



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

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

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

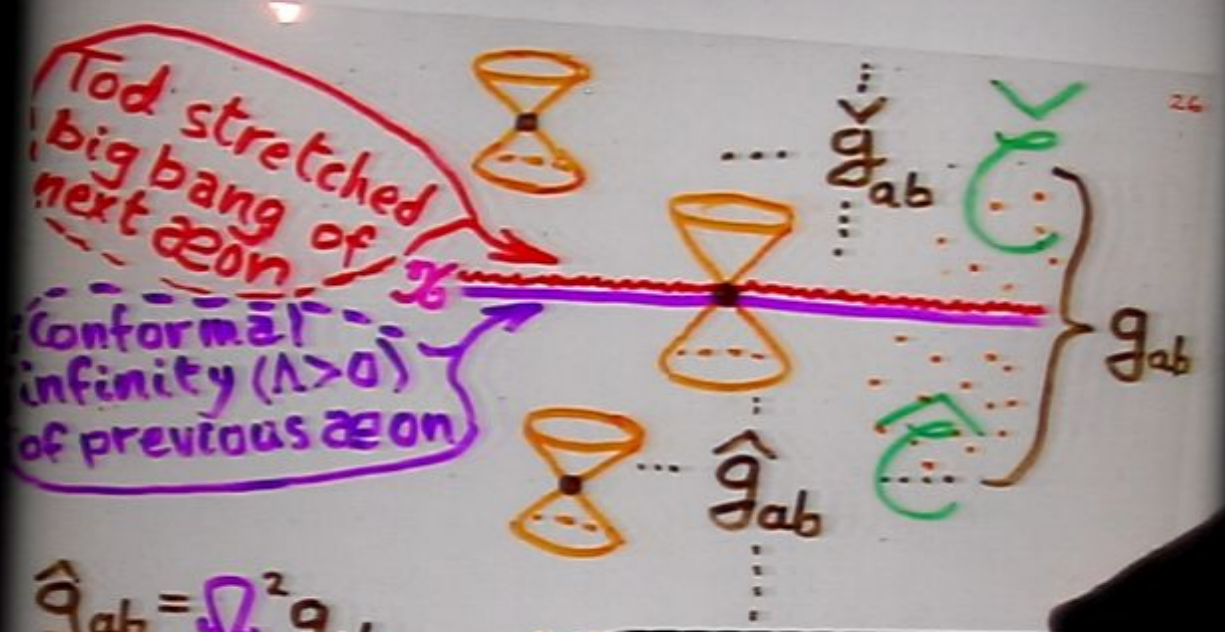
Einstein eqns.

$E_{ab} = \frac{1}{2} R g_{ab} - R_{ab}$ $\overset{\vee}{\Lambda}$ or $\overset{\wedge}{\Lambda}$

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

In $\hat{\mathscr{E}}$, 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 $\hat{\mathscr{E}}$, $\check{\mathscr{E}}$, we find that the conf.



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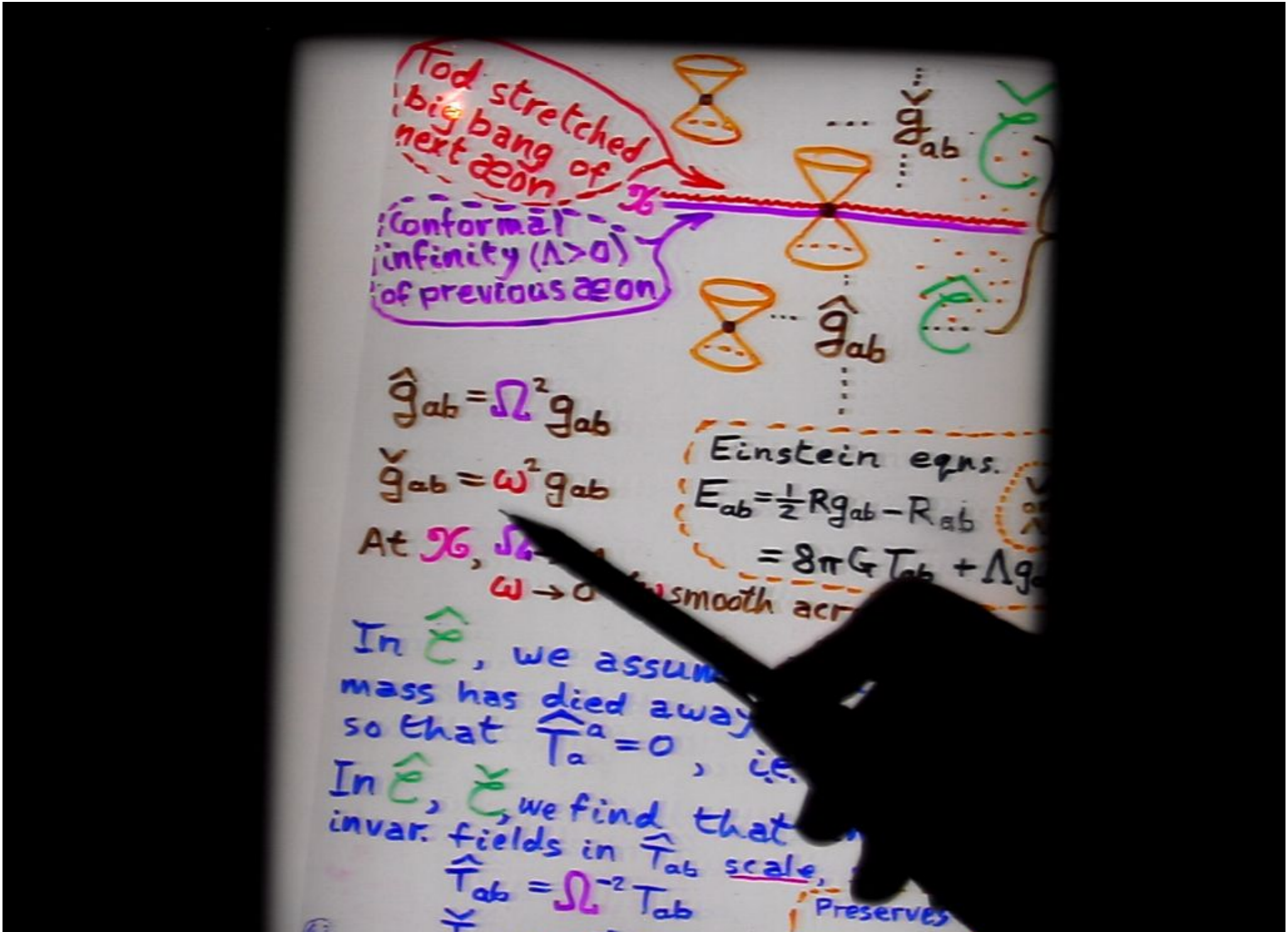
At $\mathscr{I}$, $\Omega \to \infty$
$\omega \to 0$ (ω smooth across $\mathscr{I}$)

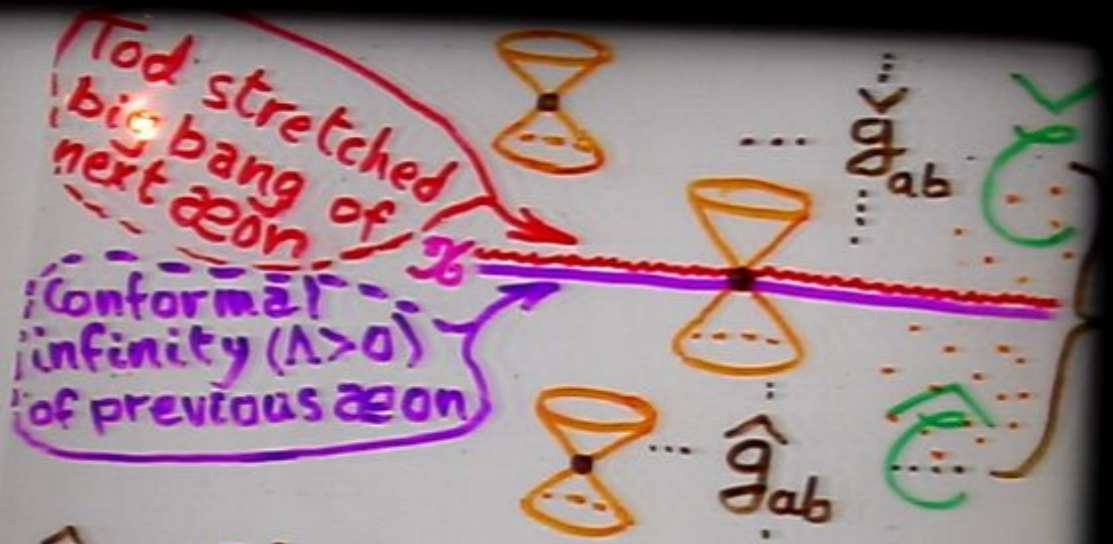
Einstein eqns.

$E_{ab} = \frac{1}{2} R g_{ab} - R_{ab}$ (or Λ)
$= 8\pi G T_{ab} + \Lambda g_{ab}$

In $\hat{\mathscr{E}}$, 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 $\hat{\mathscr{E}}$, $\check{\mathscr{E}}$, we find that the conf.


Tod stretched
big bang of
next æon
𝒥
Conformal
infinity (Λ>0)
of previous æon
$\check{g}_{ab}$
$\hat{g}_{ab}$
$\hat{g}_{ab} = \Omega^2 g_{ab}$
$\check{g}_{ab} = \omega^2 g_{ab}$
At 𝒥, Ω
ω → 0
smooth acr
Einstein eqns.
$E_{ab} = \frac{1}{2} R g_{ab} - R_{ab}$
$= 8\pi G T_{ab} + \Lambda g$
In $\hat{\mathscr{E}}$, we assum
mass has died away
so that $\hat{T}^a_a = 0$, i.e.
In $\hat{\mathscr{E}}$, $\check{\mathscr{E}}$, we find that
invar. fields in $\hat{T}_{ab}$ scale,
$\hat{T}_{ab} = \Omega^{-2} T_{ab}$
Preserves



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

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

At $\mathscr{I}$, $\Omega \to 0$

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

Einstein eqns.

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

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

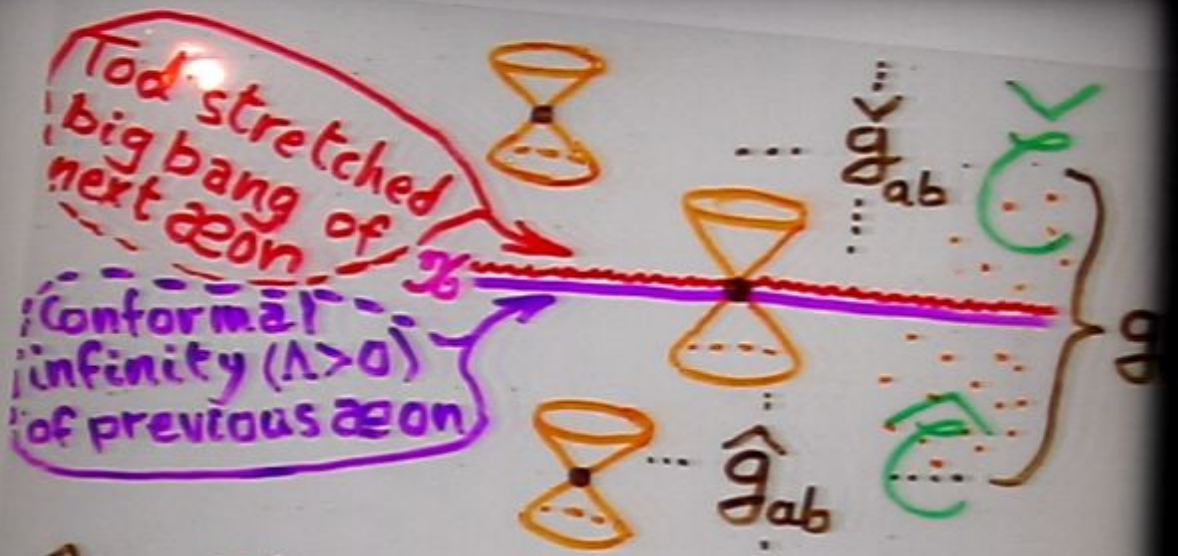
In $\hat{\mathscr{E}}$, we assume that all rest mass has died away (CCC hypothesis) so that $\hat{T}^a_a = 0$, i.e. $\hat{R} = 4\Lambda$.

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

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

Preserves

$\check{T}$



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

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At $\mathscr{I}$, $\Omega \to 0$

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

Einstein eqns.

$E_{ab} = \frac{1}{2} R g_{ab} - R_{ab}$ (V or Λ)

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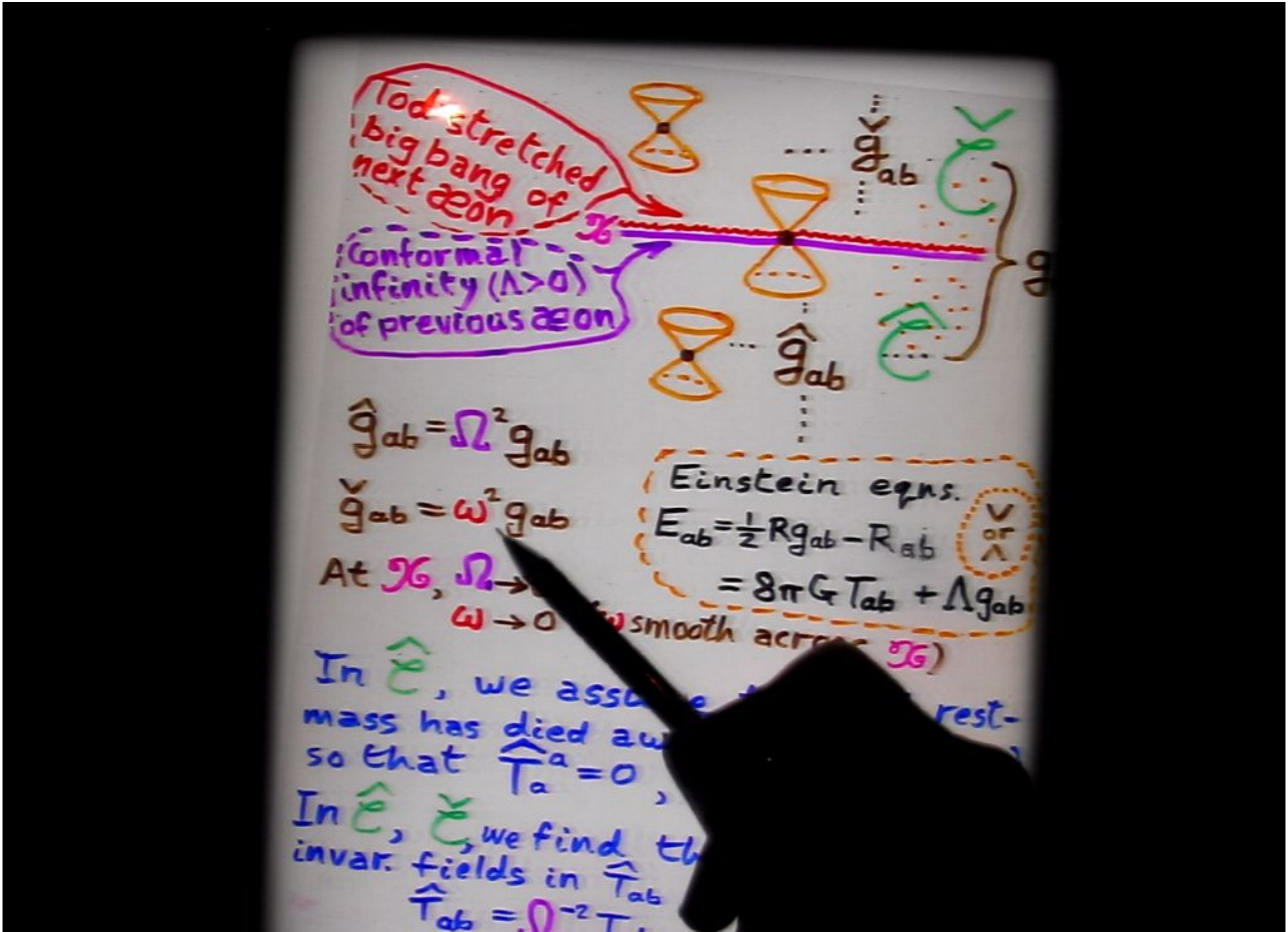
Tod stretched big bang of next æon
conformal infinity (Λ>0) of previous æon
$\mathscr{I}$
$\check{g}_{ab}$
$\hat{g}_{ab}$
g_{ab}
$\hat{g}_{ab} = \Omega^2 g_{ab}$
$\check{g}_{ab} = \omega^2 g_{ab}$
At $\mathscr{I}$, $\Omega \to$
$\omega \to 0$
smooth
Einstein eqns.
$E_{ab} = \frac{1}{2} R g_{ab} - R_{ab}$
$= 8\pi G T_{ab} + \Lambda g_{ab}$
$\check{}$ or Λ
In $\hat{\mathscr{E}}$, we
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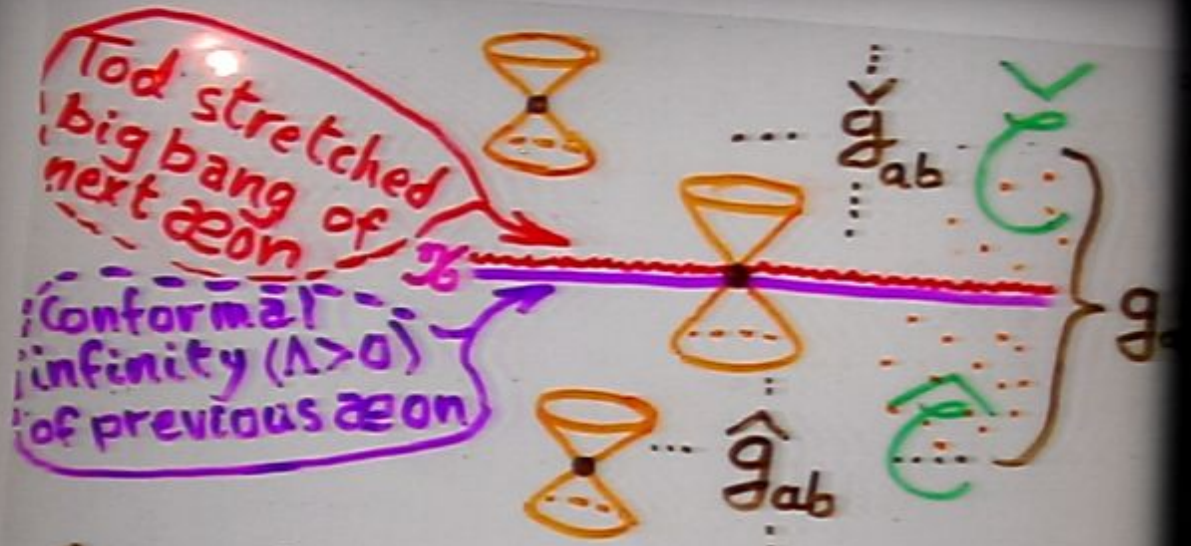
so that $\hat{T}^a_a = 0$,
In $\hat{\mathscr{E}}$, $\check{\mathscr{E}}$, we find
invar. fields in $\hat{T}_{ab}$
$\hat{T}_{ab} = \Omega^{-2} T$



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

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

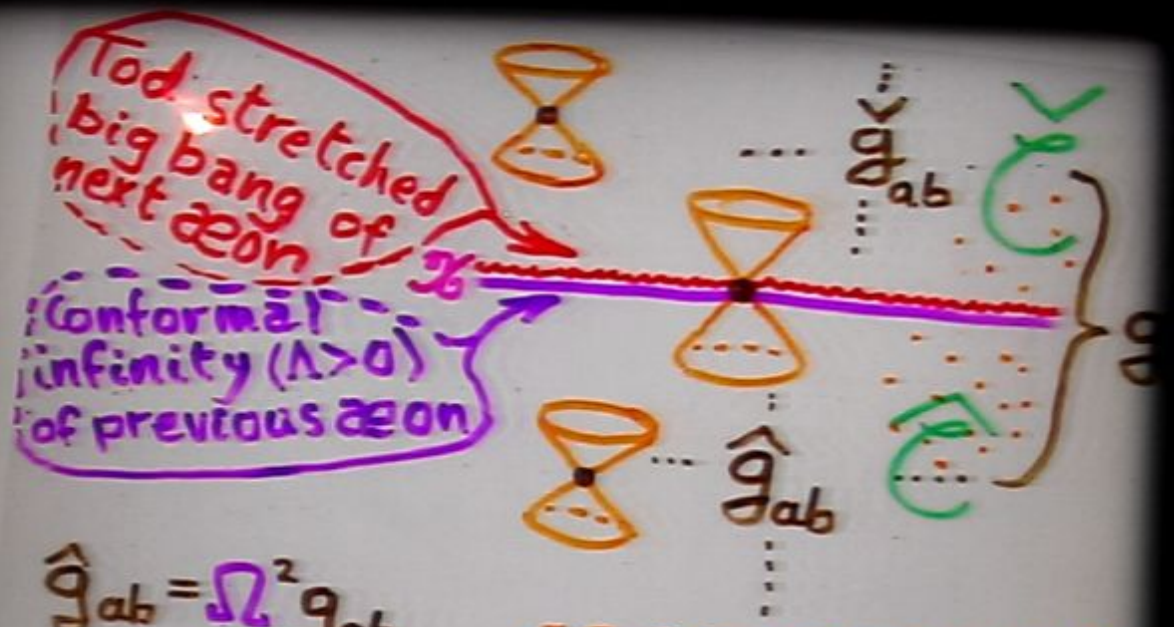
Einstein eqns. ($\check{V}$ or $\hat{\Lambda}$)

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

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

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



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

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

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

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

Einstein eqns.

$E_{ab} = \frac{1}{2} R g_{ab} - R_{ab}$ ($\overset{\vee}{\Lambda}$ or Λ)

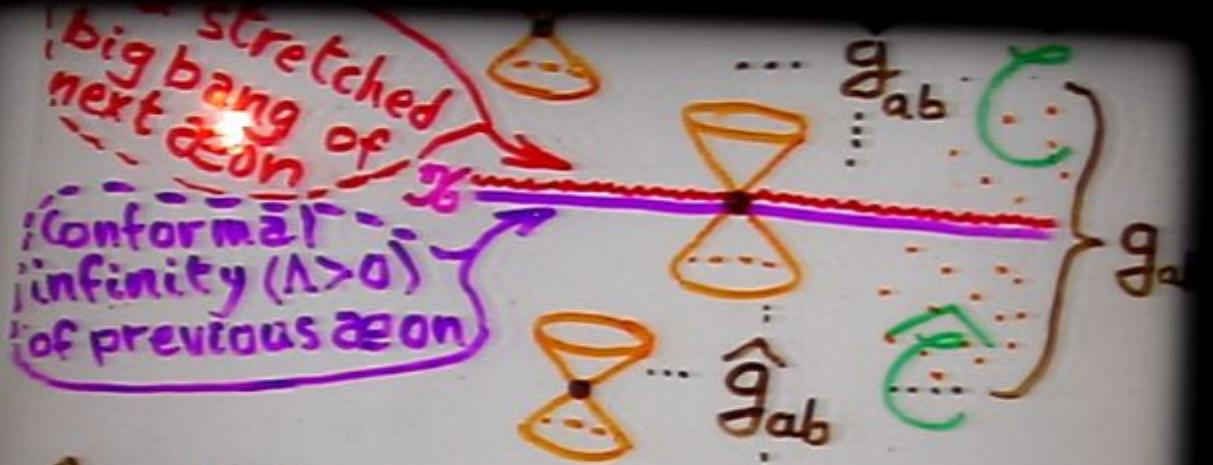
$= 8\pi G T_{ab} + \Lambda g_{ab}$

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

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

Preserves $\overset{\vee}{\Lambda}$



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

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

Einstein eqns. ($\check{}$ or $\hat{}$)

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

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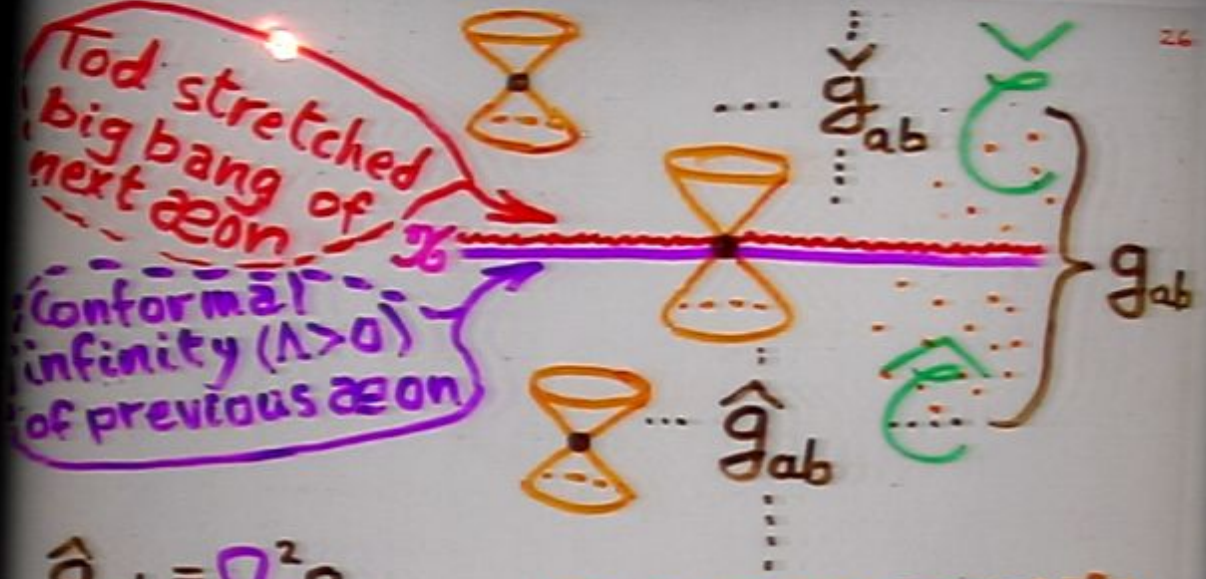
In $\hat{\mathscr{E}}$, $\check{\mathscr{E}}$, we find that the conf. invar. fields in $\hat{T}_{ab}$ scale, so that

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

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

Preserves ($\check{}$ or $\hat{}$)

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



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At $\mathscr{I}$, $\Omega \to 0$

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Einstein eqns.

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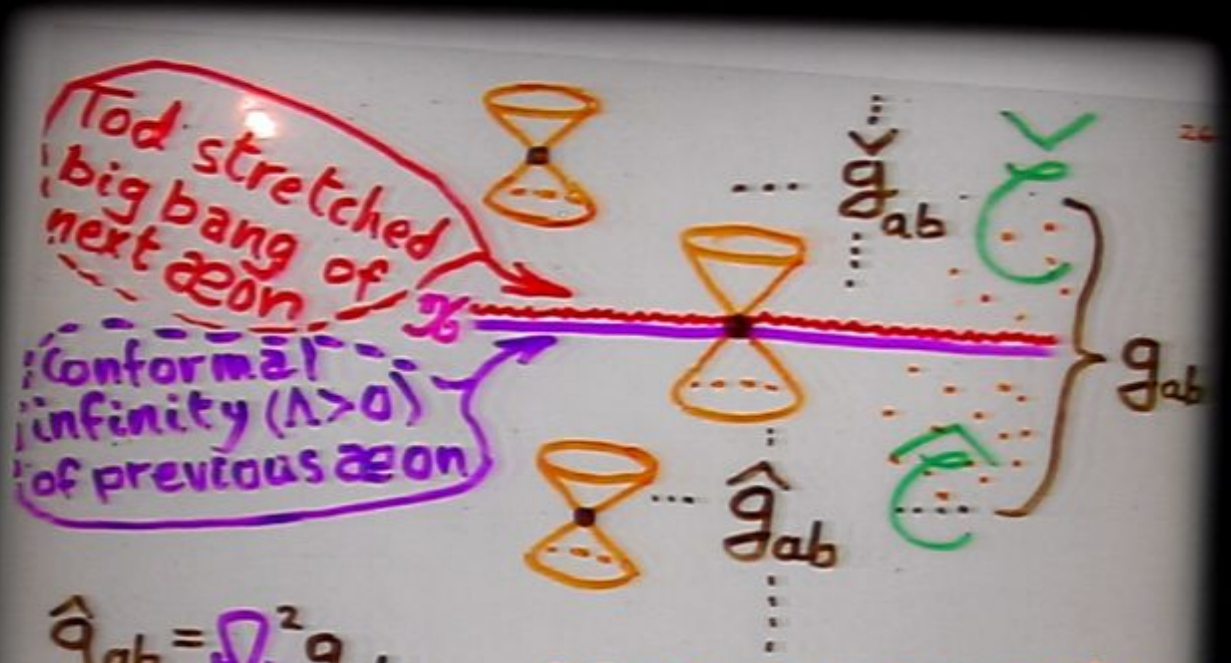

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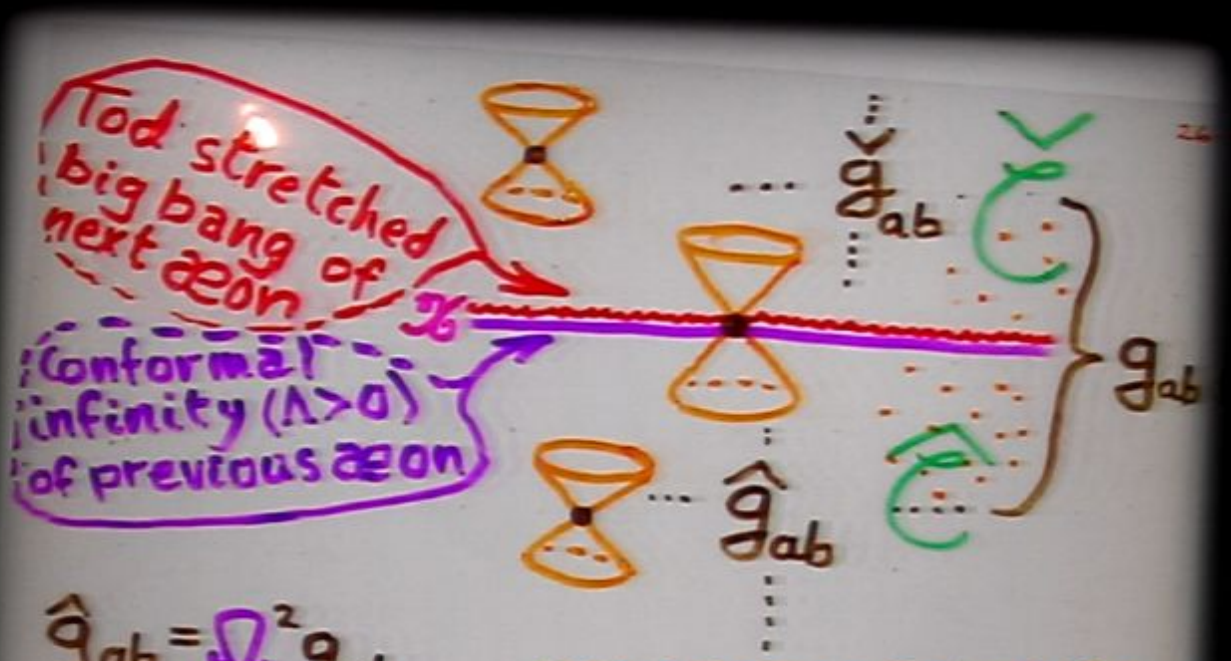

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At $\mathscr{I}$, $\Omega \to \infty$

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

Einstein eqns.

$E_{ab} = \frac{1}{2} R g_{ab} - R_{ab}$ ($\overset{\vee}{\Lambda}$ or Λ)

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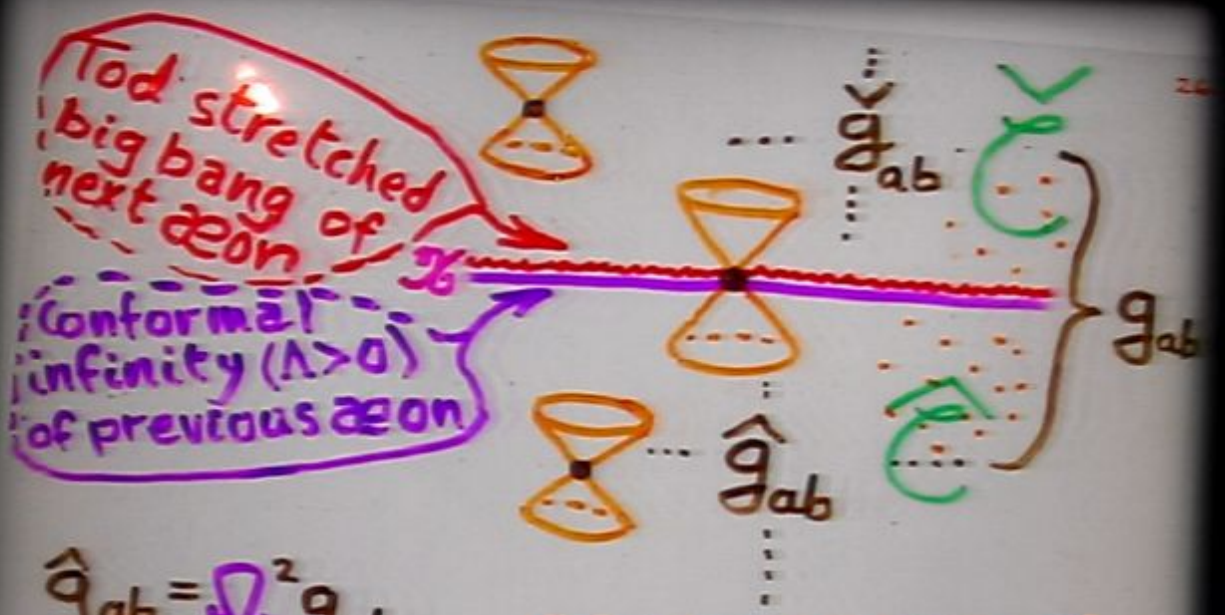

$\hat{g}_{ab} = \Omega^2 g_{ab}$

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

Einstein eqns.

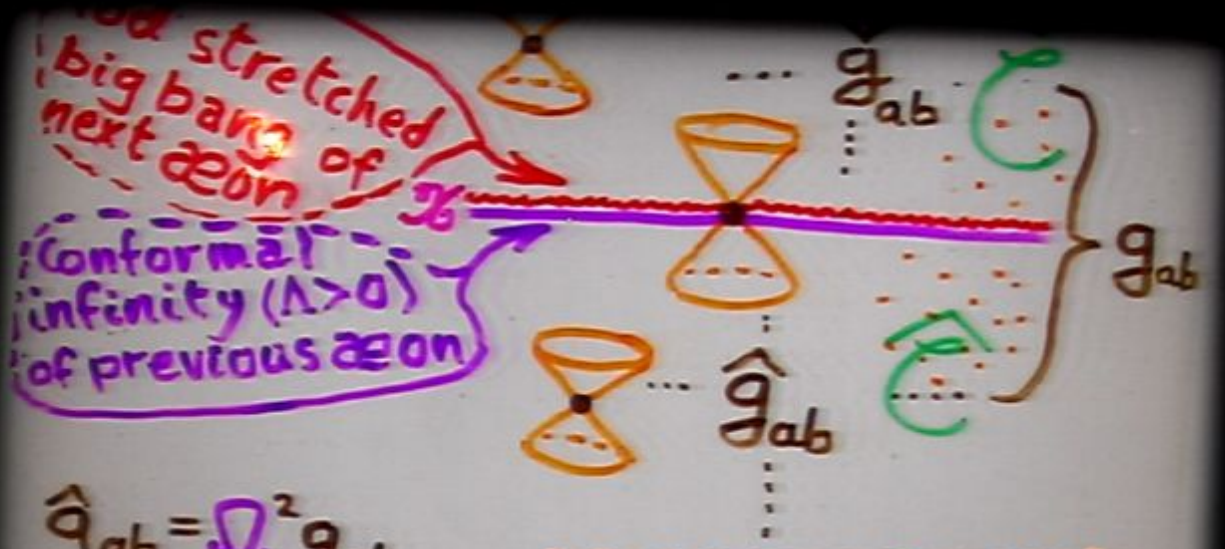
$E_{ab} = \frac{1}{2} R g_{ab} - R_{ab}$

$= 8\pi G T_{ab} + \Lambda g_{ab}$ (Λ or ∨)

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

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



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

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

At $\mathscr{I}$, $\Omega \to 0$

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

Einstein eqns.

$E_{ab} = \frac{1}{2} R g_{ab} - R_{ab}$ (or $\check{\Lambda}$)

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

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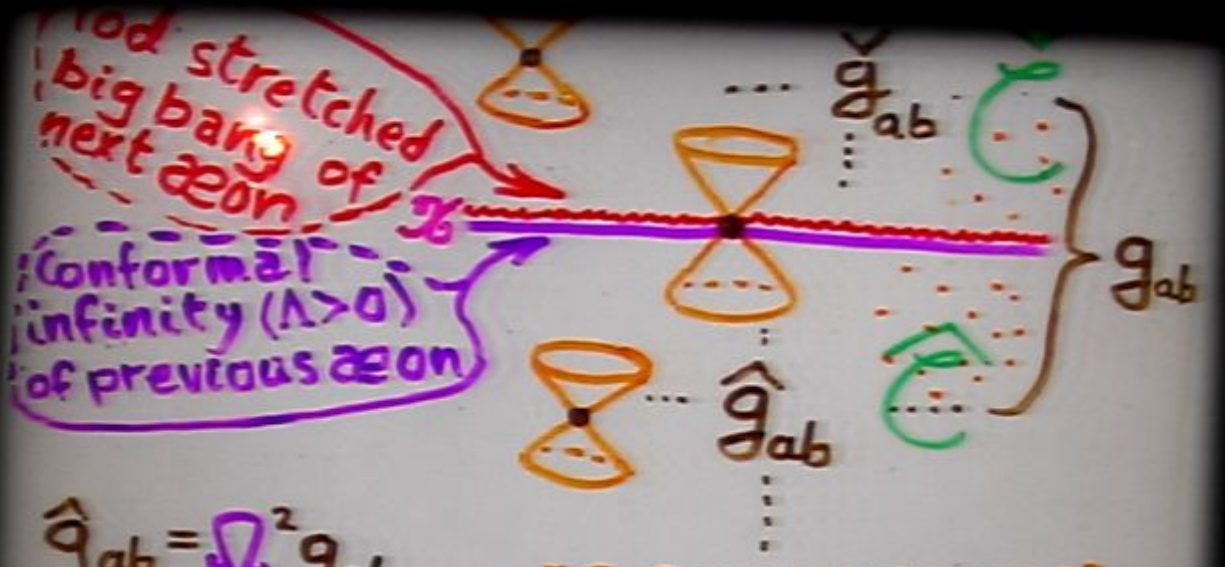
Preserves (or $\check{\Lambda}$)

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



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At $\mathscr{I}$, $\Omega \to \infty$
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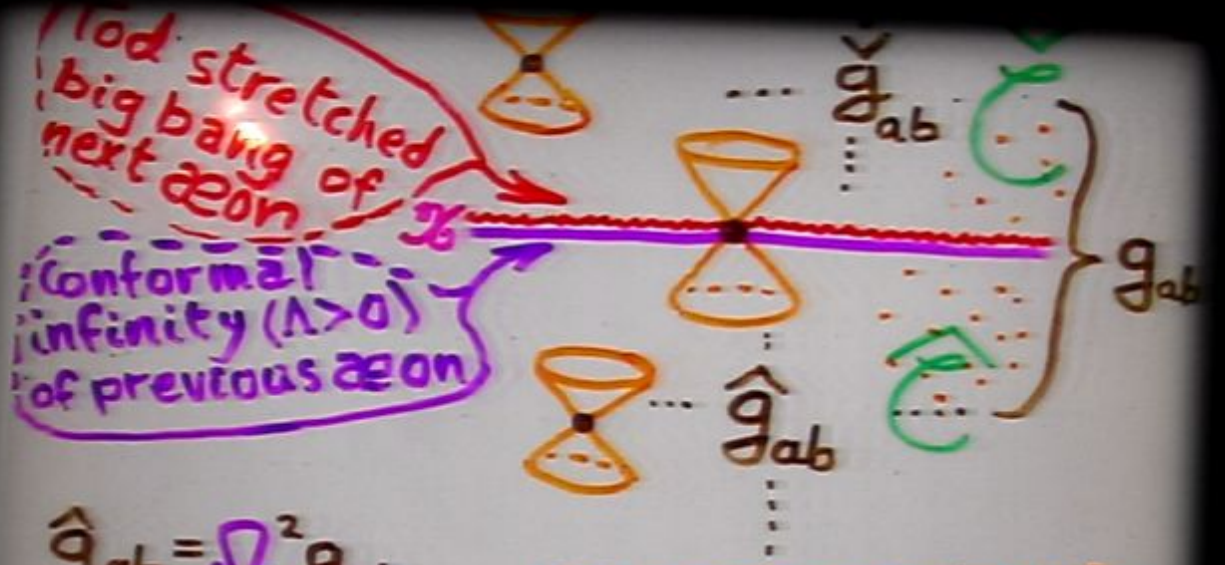
Preserves $\nabla^a T_{ab} = 0$ (or $\check{\nabla}$ or $\hat{\nabla}$)



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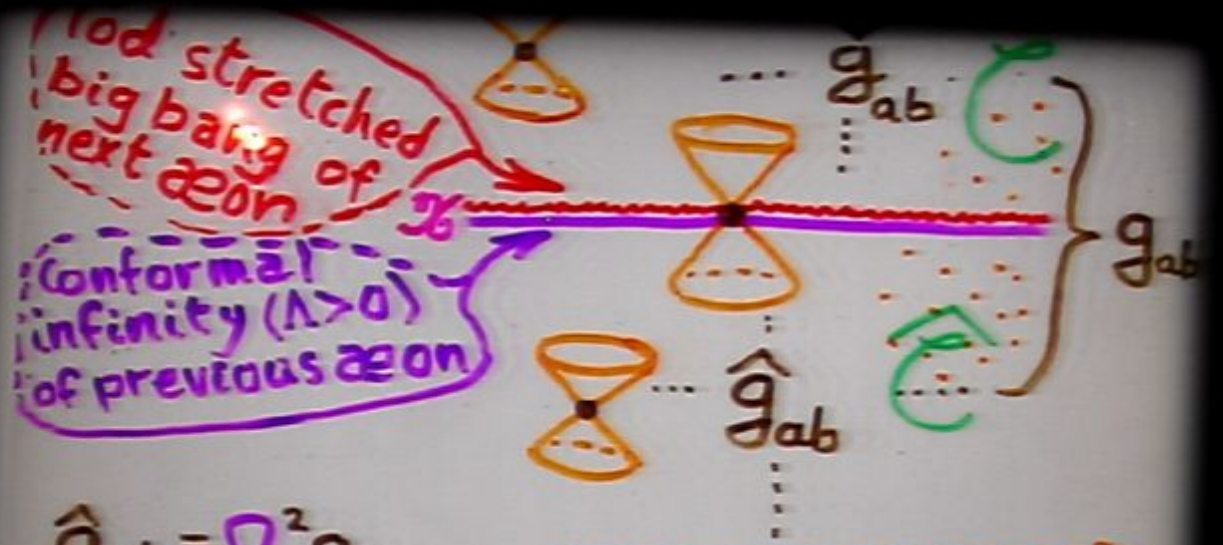

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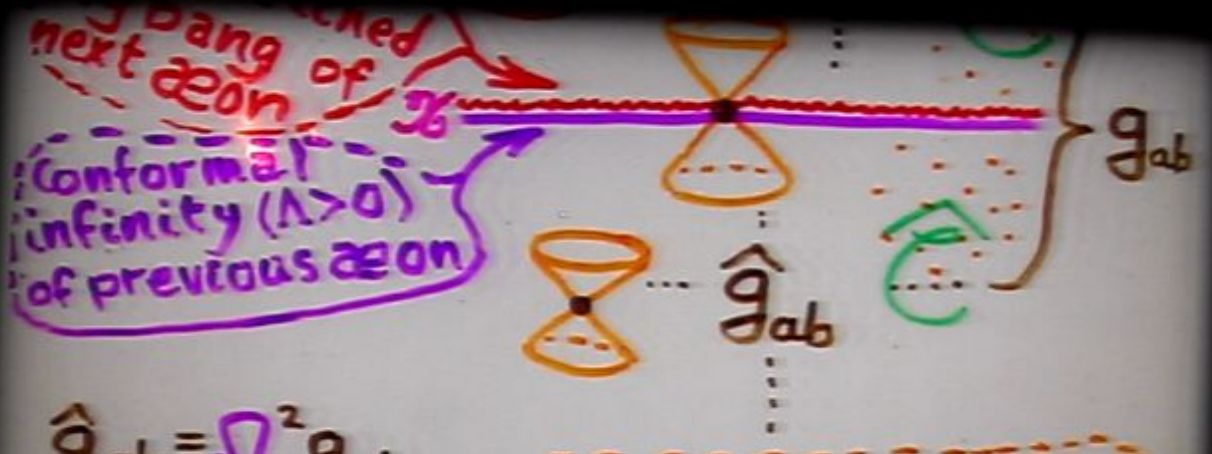

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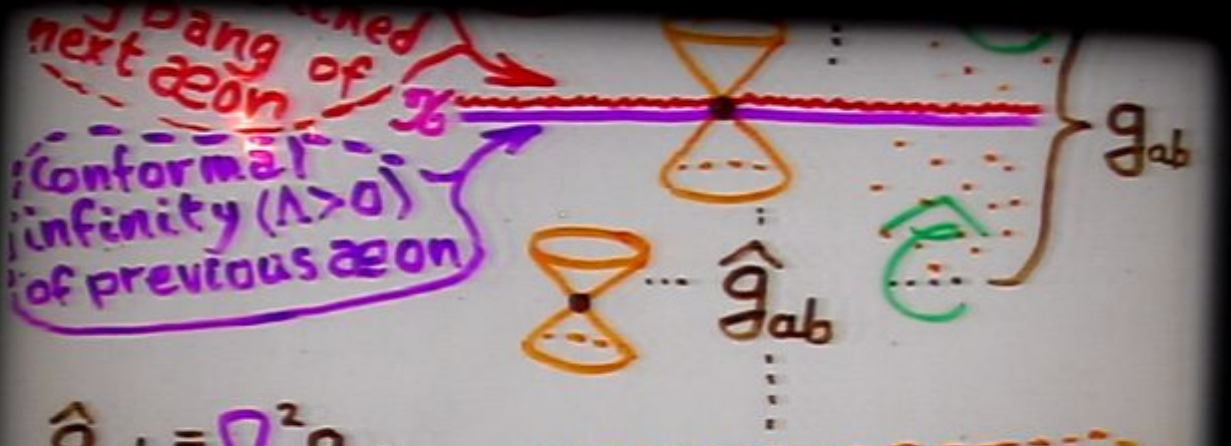
Preserves ($\vee$ or $\wedge$)

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



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Einstein eqns. (V or Λ)

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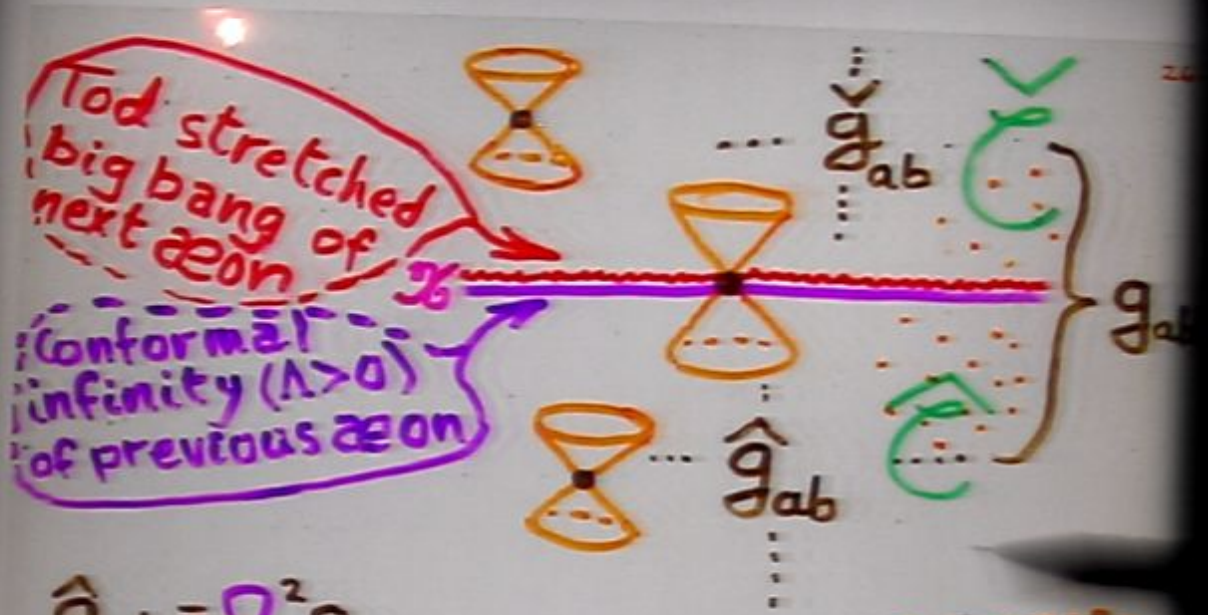
Preserves $\nabla^a T_{ab} = 0$ (V or Λ)



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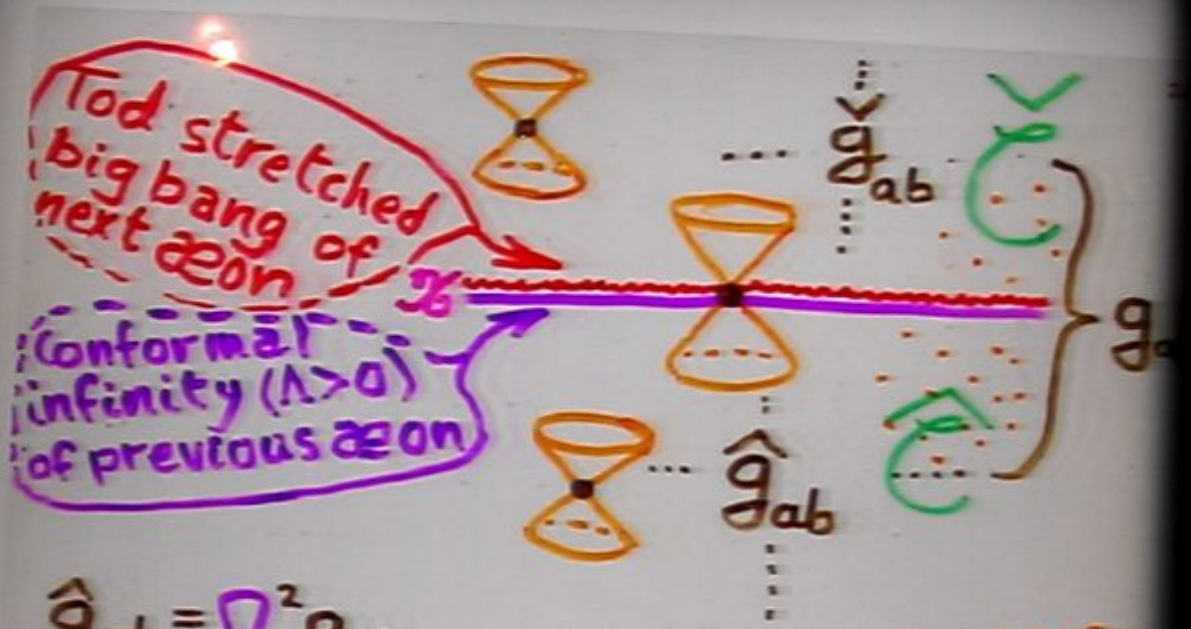

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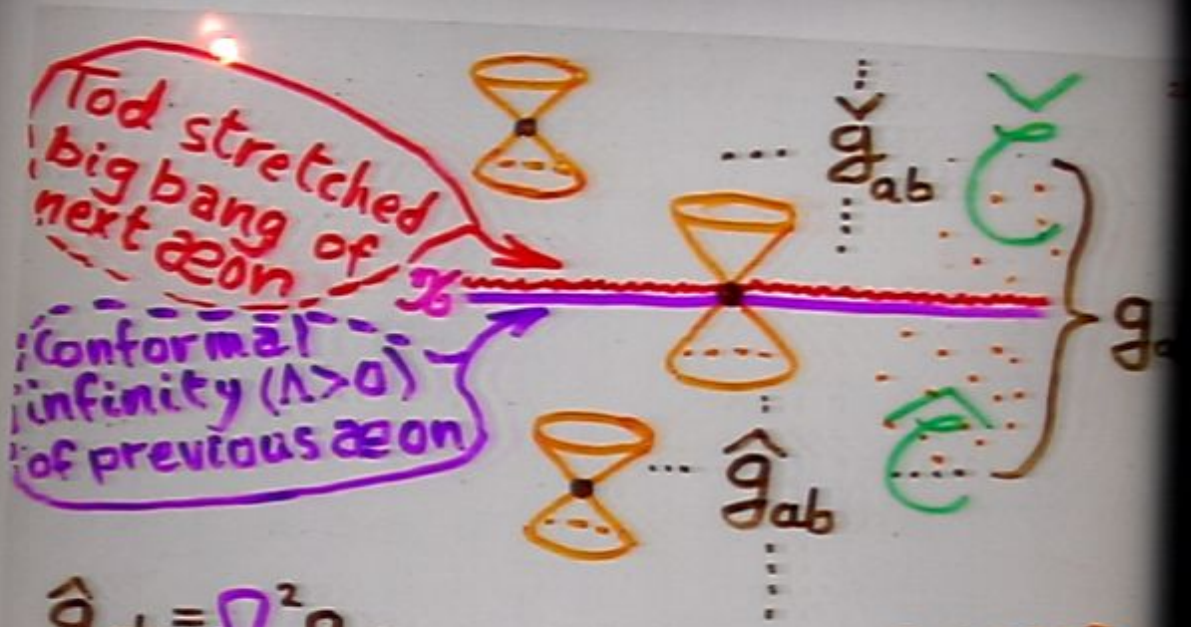

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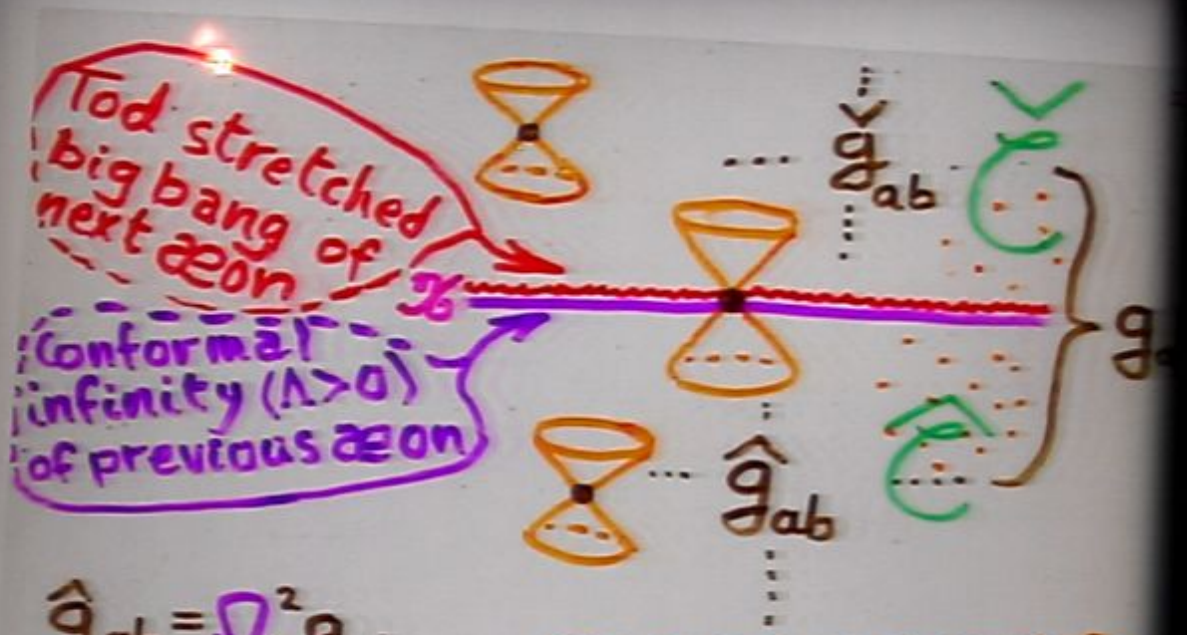

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$\overset{\vee}{g}_{ab} = \omega^2 g_{ab}$

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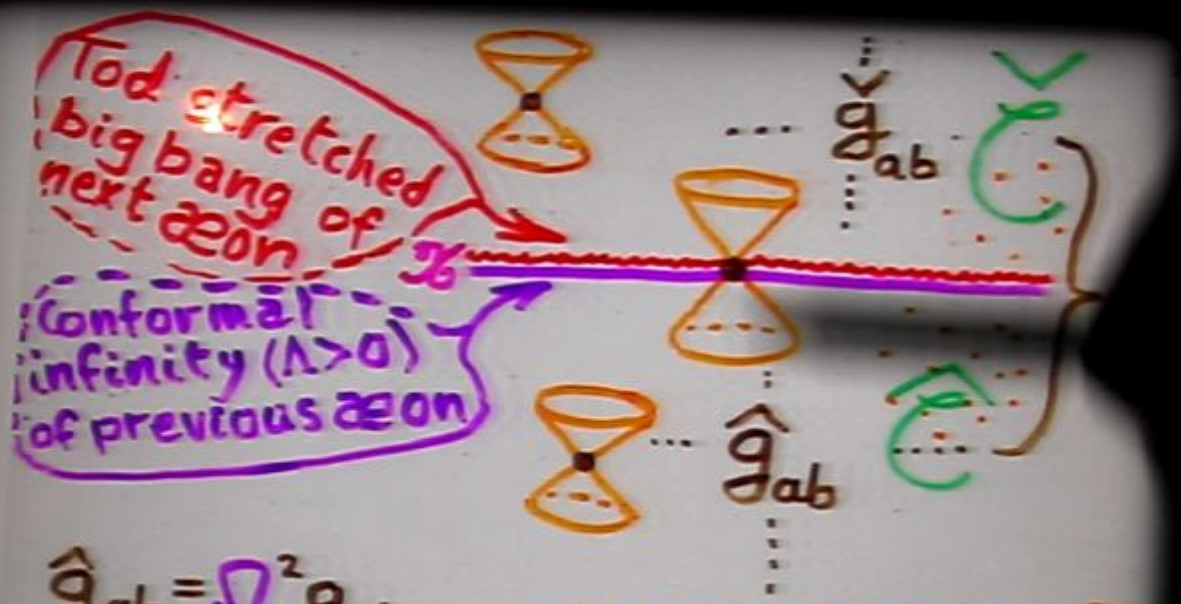

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Einstein eqns. ($\check{}$ or $\hat{}$)

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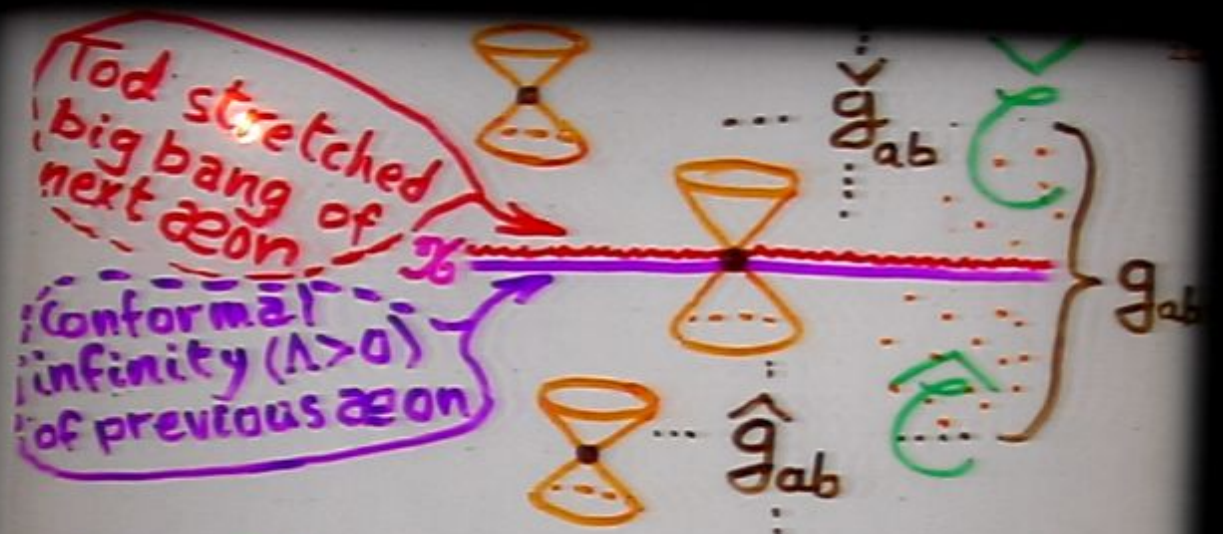
Preserves ($\check{}$ or $\hat{}$)



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

At $\mathscr{I}$, $\Omega \to \infty$
$\omega \to 0$ (ω smooth across $\mathscr{I}$)

Einstein eqns. ($\check{V}$ or $\hat{\Lambda}$)

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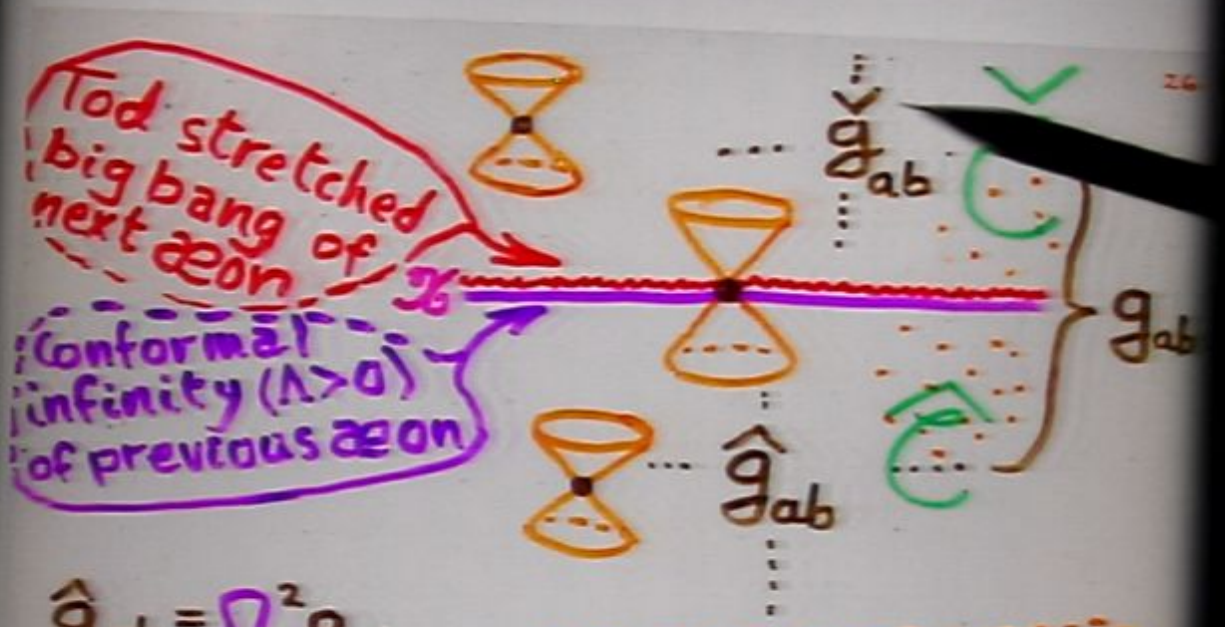
Preserves ($\check{V}$ or $\hat{\Lambda}$)

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



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

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

Einstein eqns.

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

$\vee$ or $\wedge$

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

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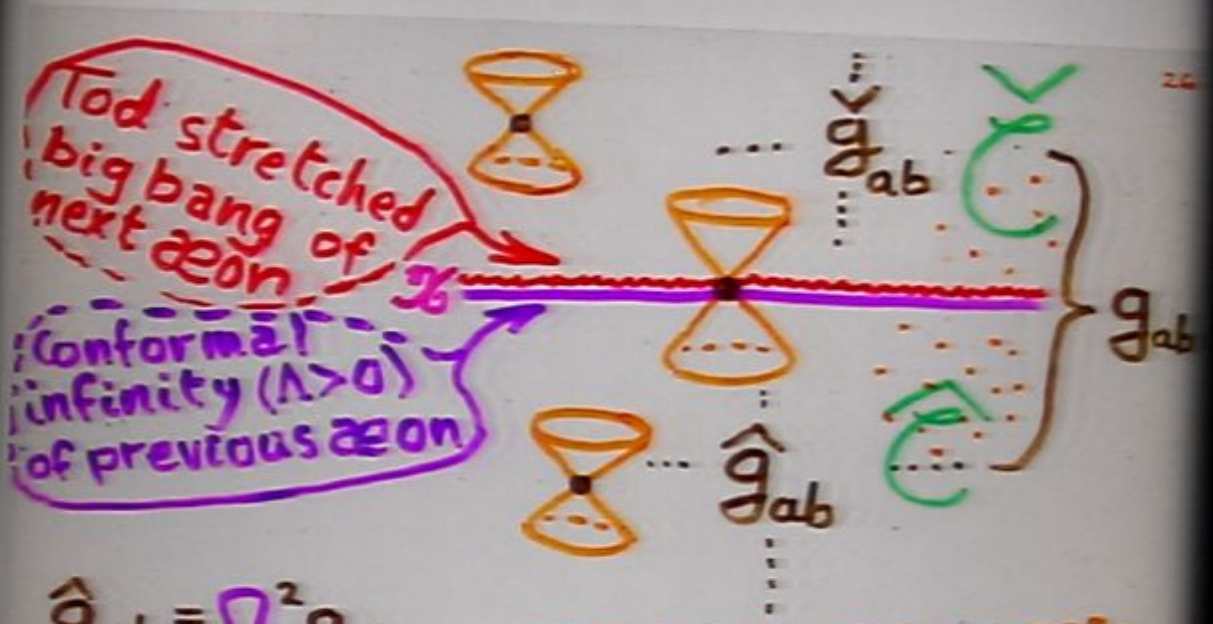

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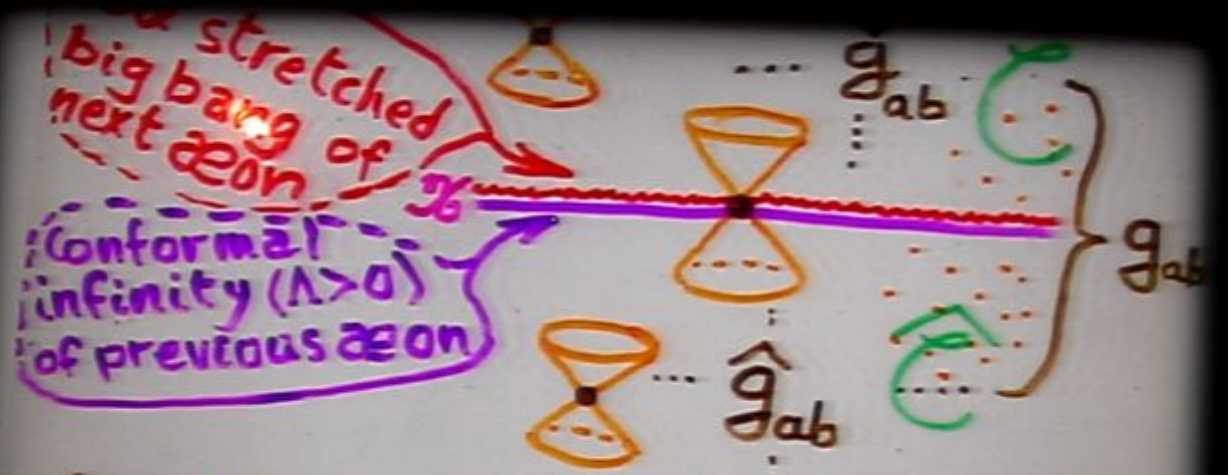

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At $\mathscr{I}$, $\Omega \to \infty$

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

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Preserves ($\vee$ or $\wedge$)

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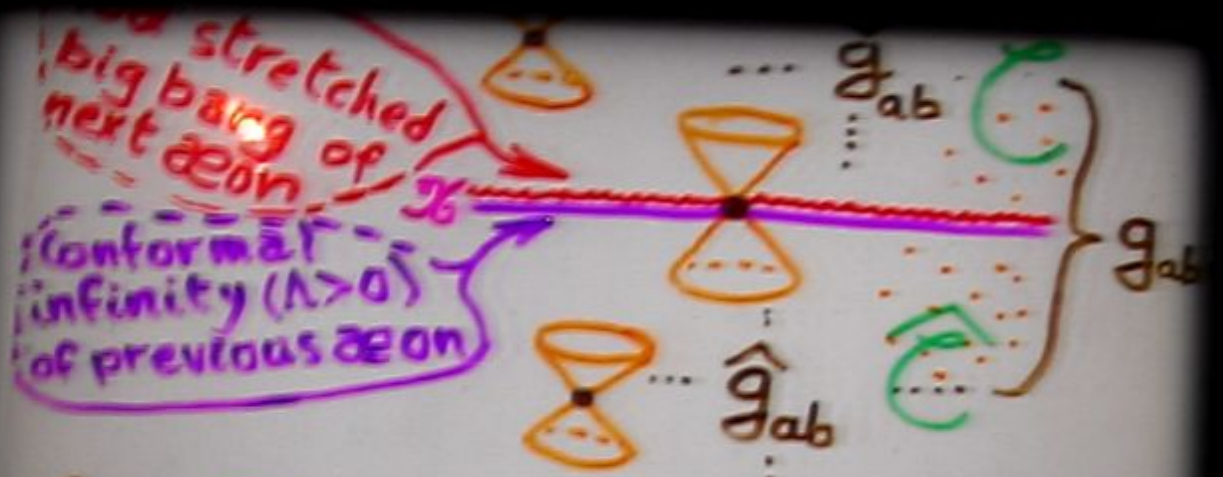

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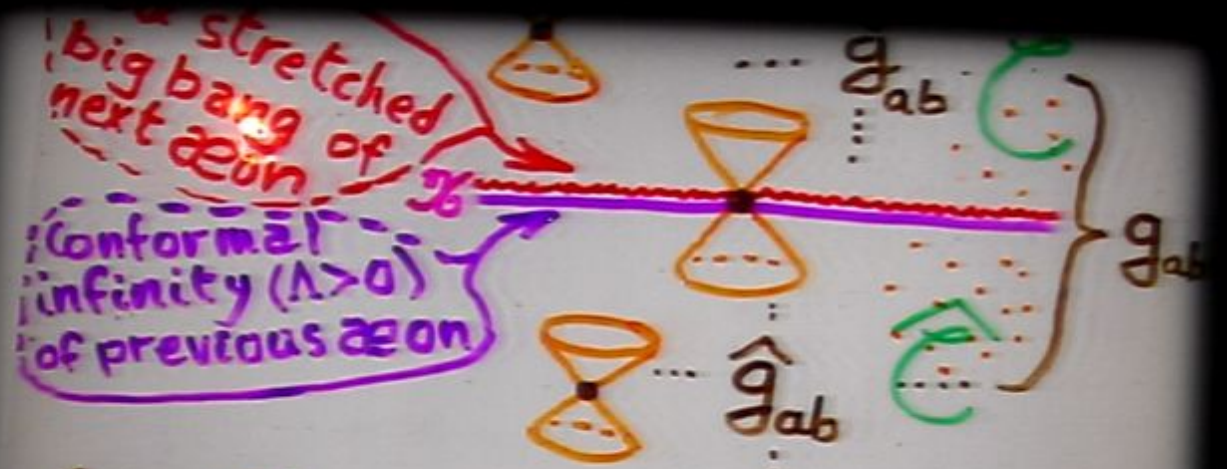

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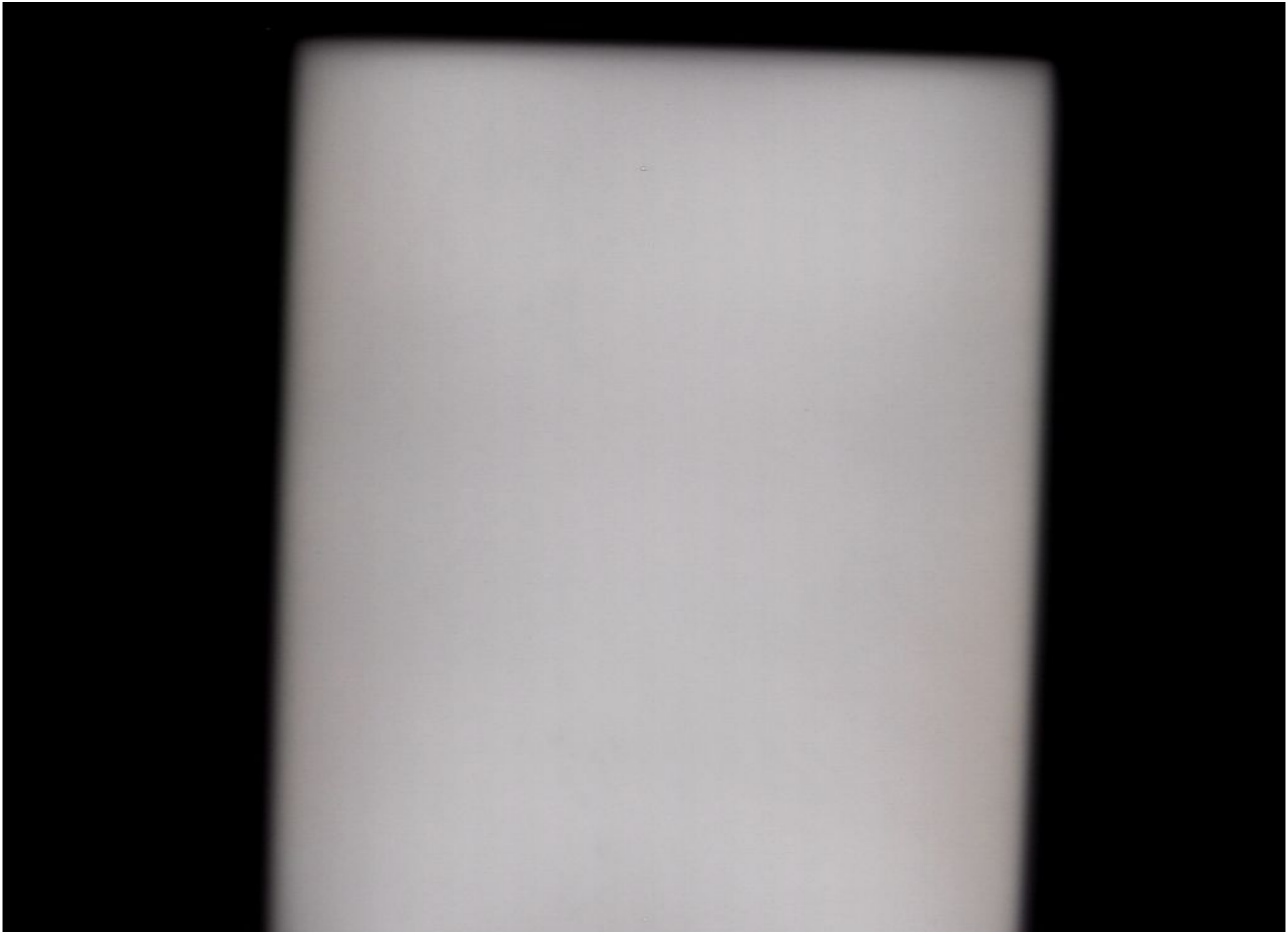
Preserves $\nabla^a T_{ab} = 0$ (∨ or ∧)



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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 $\check{R} = 4\Lambda + 8\pi G\mu$

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 [illegible] $\omega = \Omega$ sats. the

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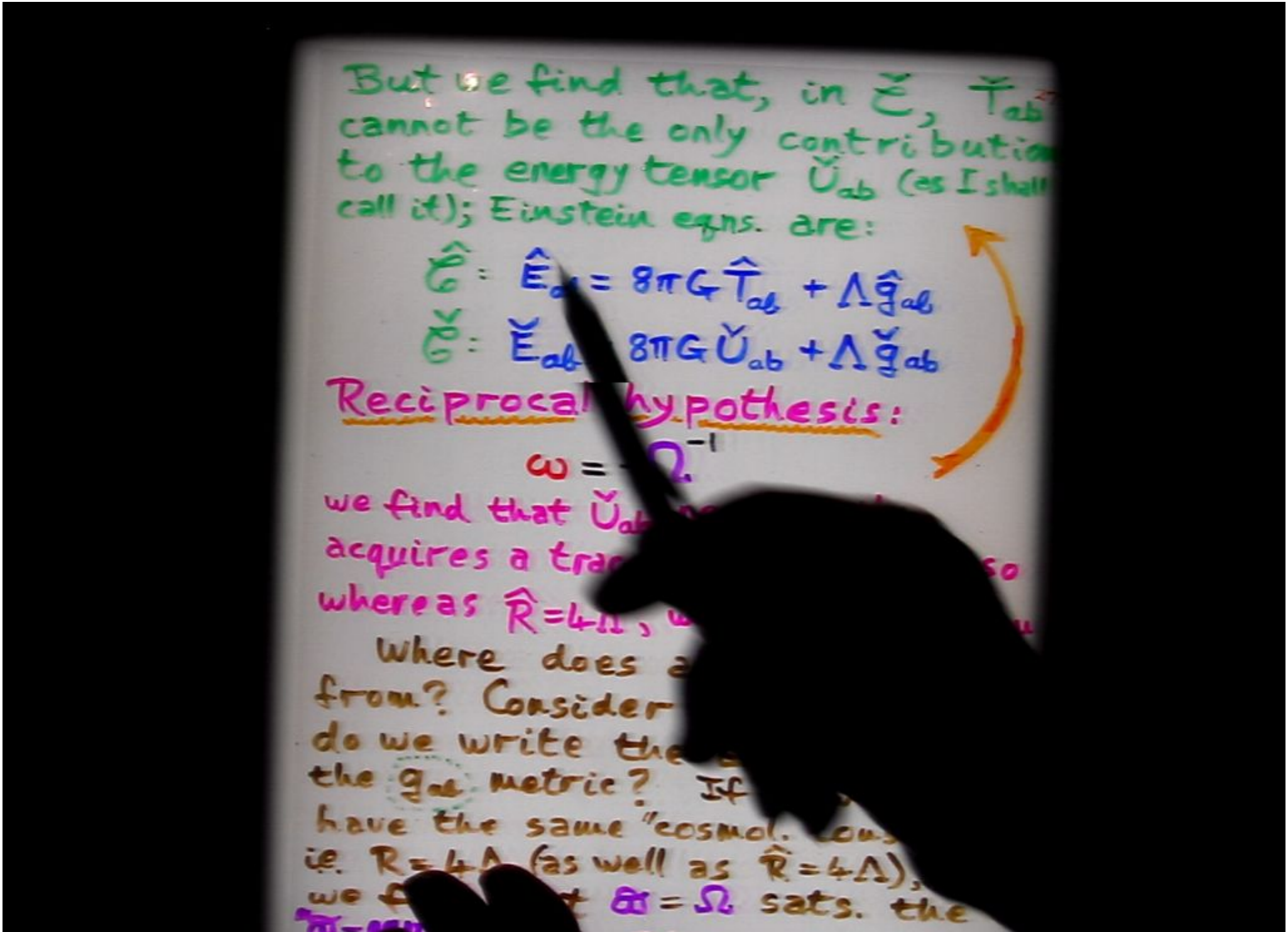
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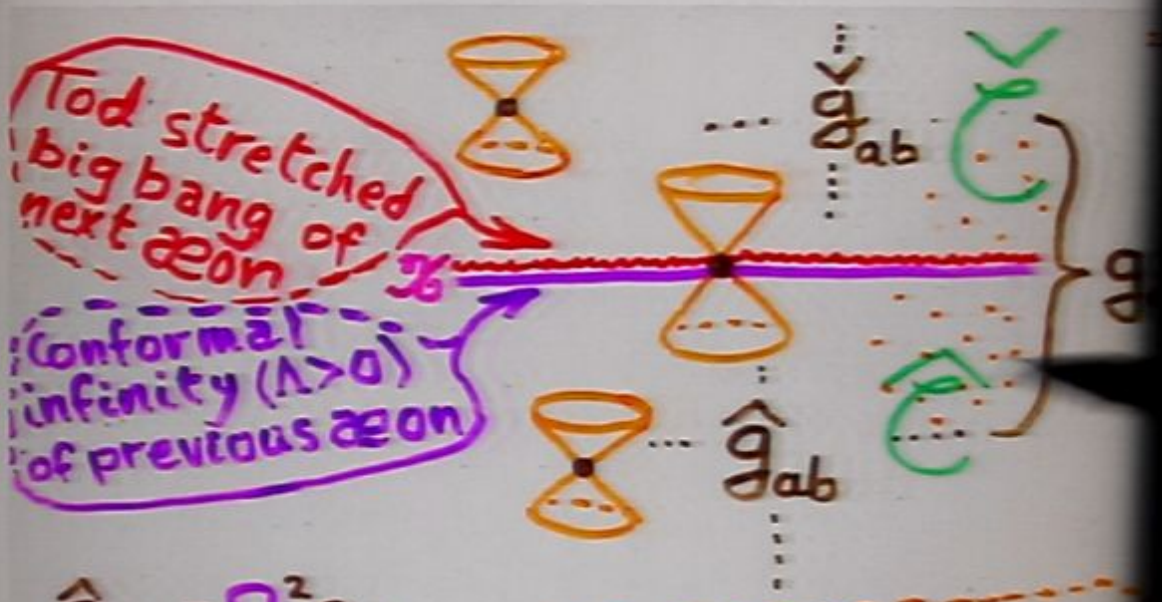

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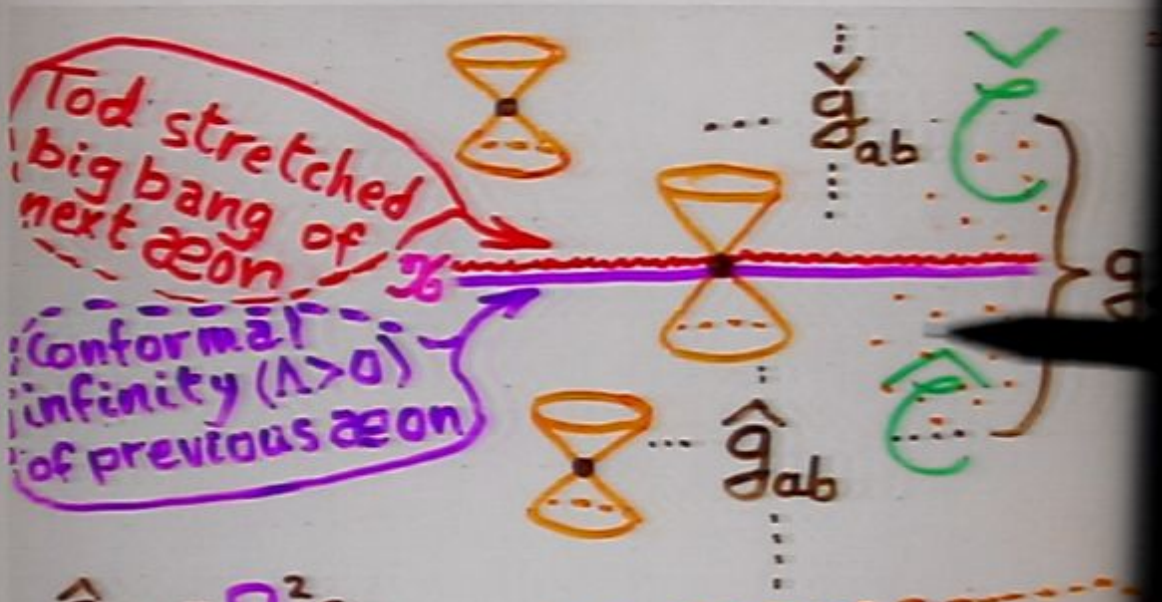

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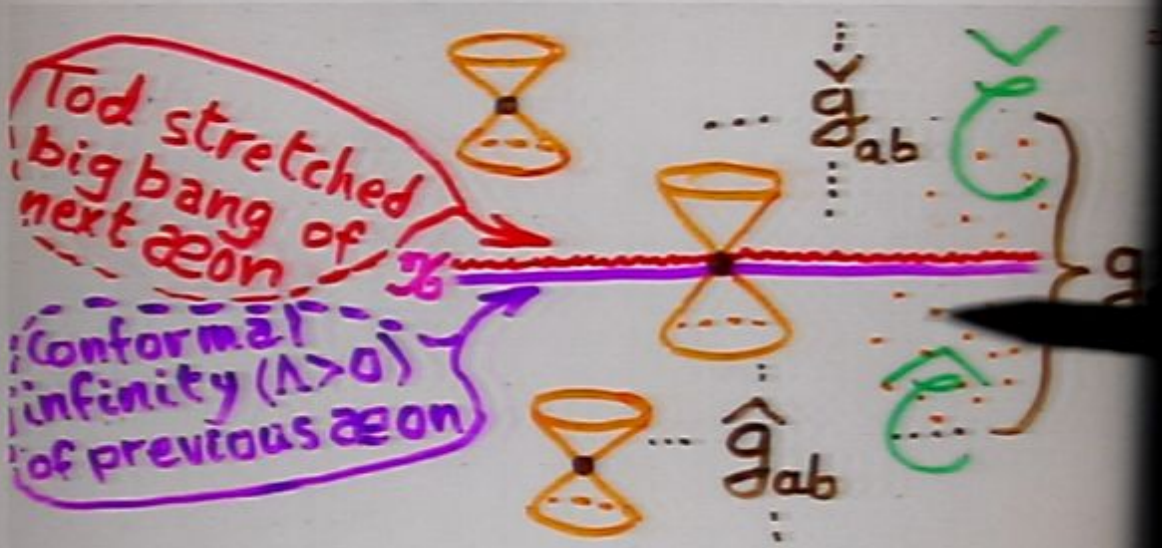

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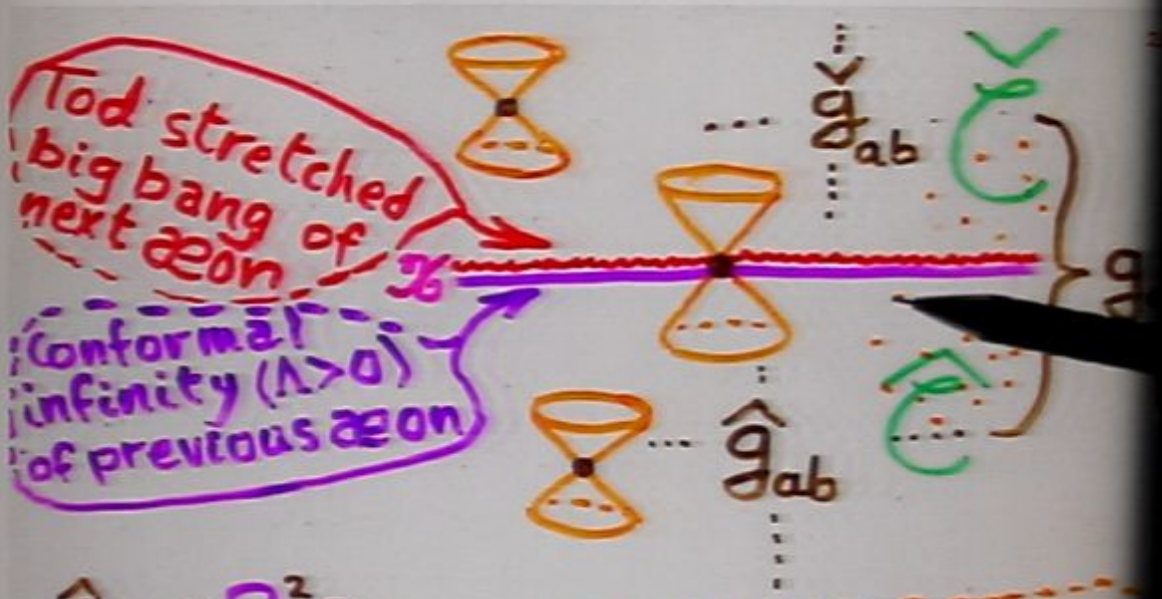

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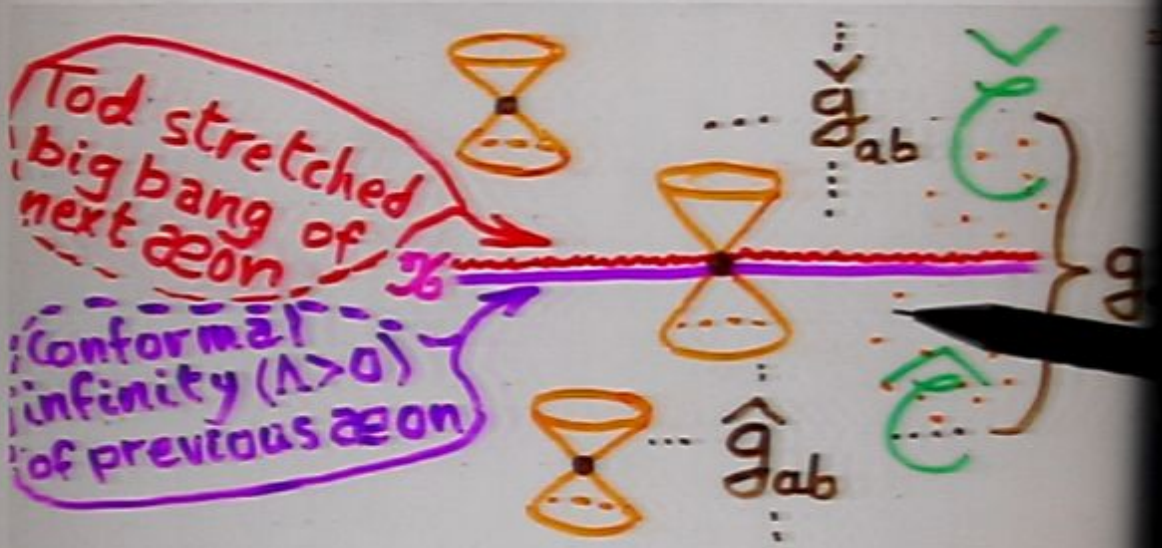

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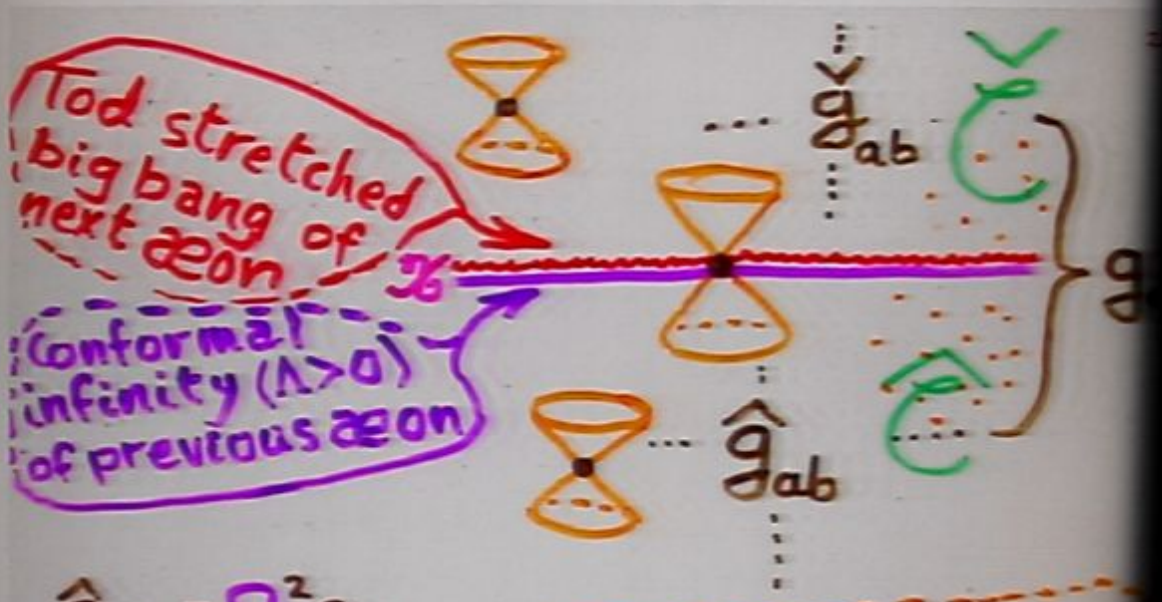

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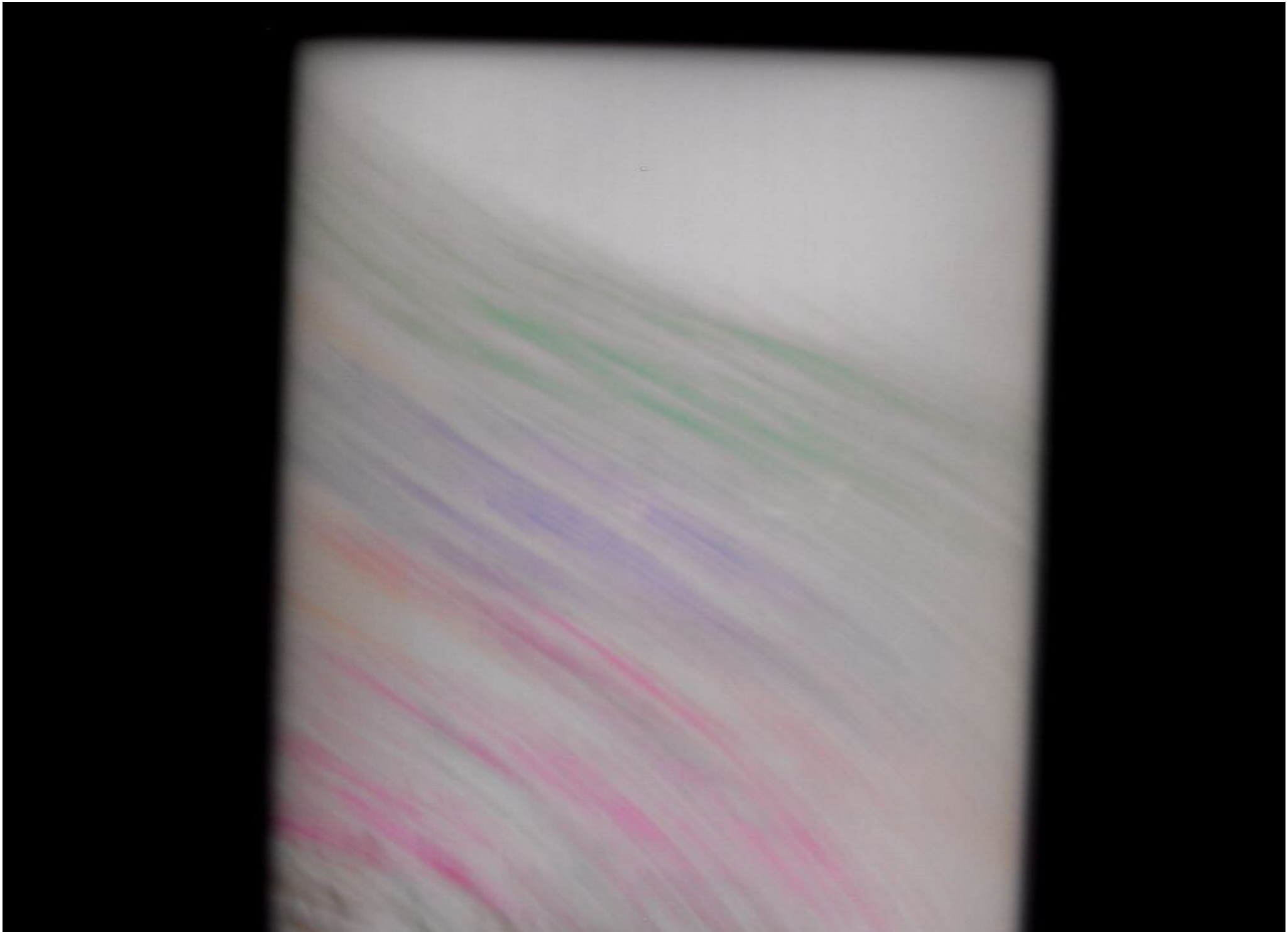

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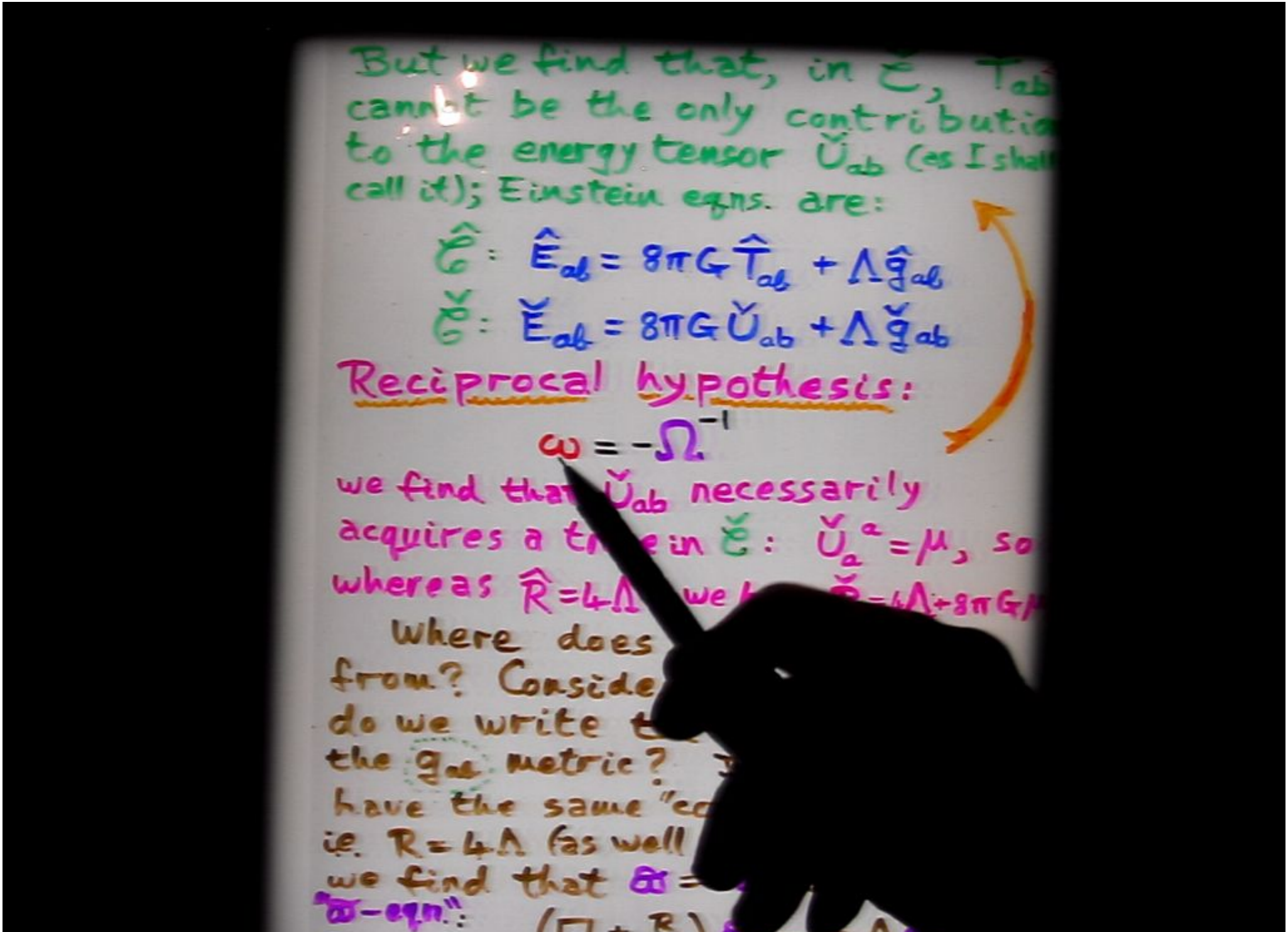
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The energy ("new improved") tensor for Ω is:

Callan Coleman Jackiw Newman-RP

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Specific choice of const. made

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

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

Call Ω the "phantom field"

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Callan Coleman Jackiw Newman-RP

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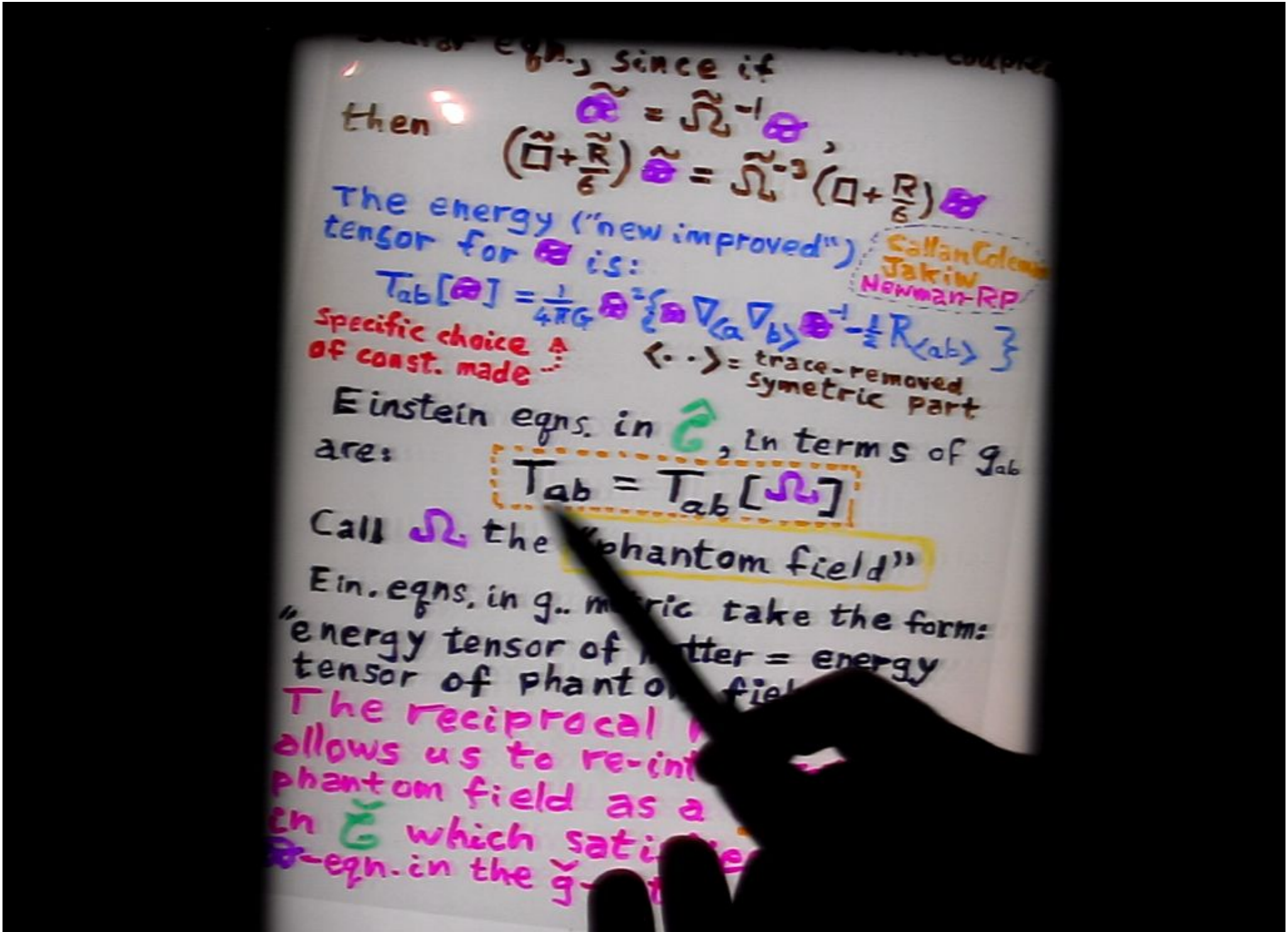

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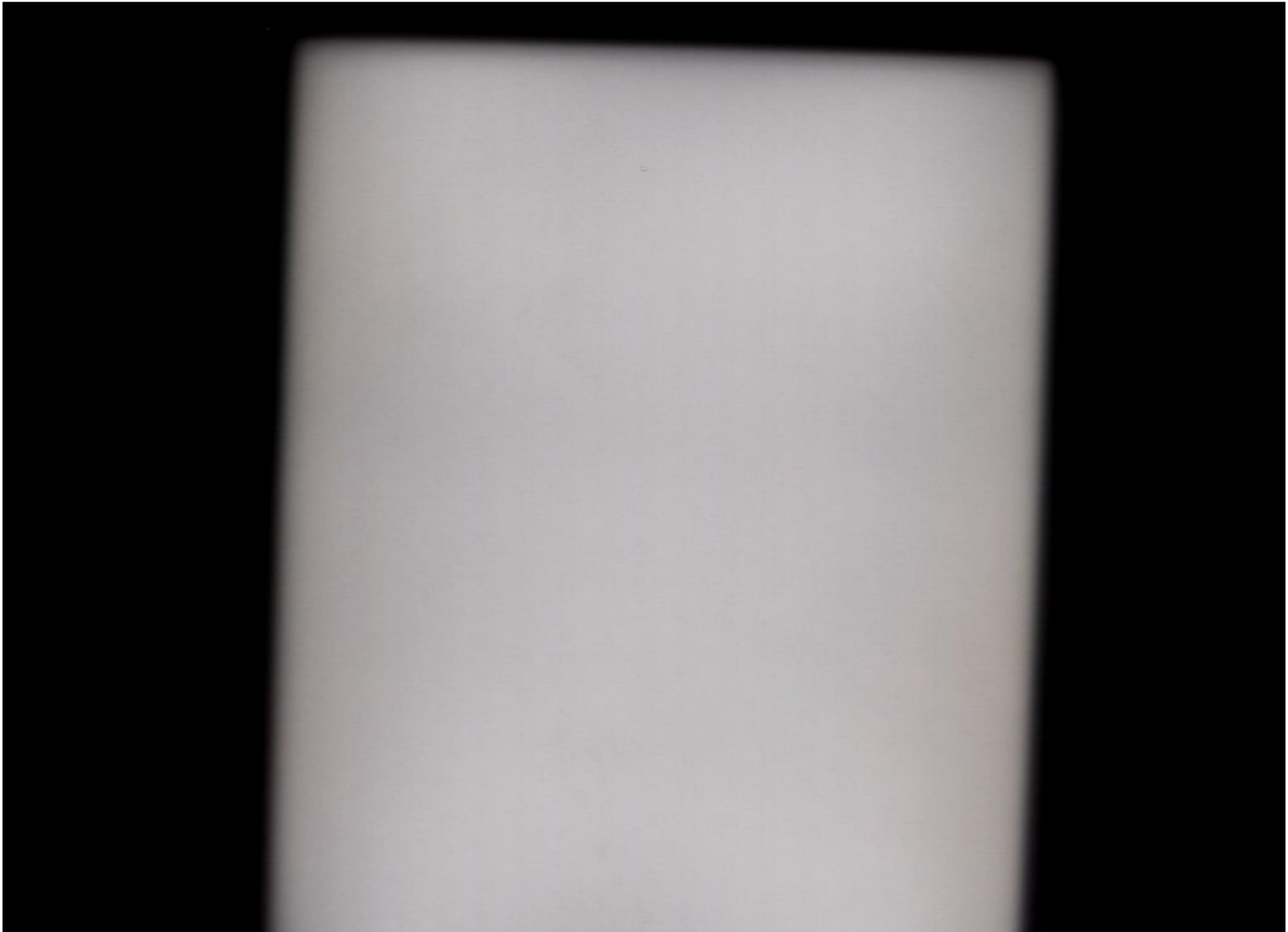

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The 1-form

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

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Reciprocal hypothesis:

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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":

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For convenience, we can scale things so that $R=12$ i.e. $\Lambda=3$.

Then the equation on Ω becomes

$$\tfrac{1}{2}\nabla_a\nabla^a\Omega+\Omega-\Omega^3=0$$

We find that this equation is equivalent to

$$2\Omega(1-\Pi_a\Pi^a)=\nabla^a\Pi_a$$

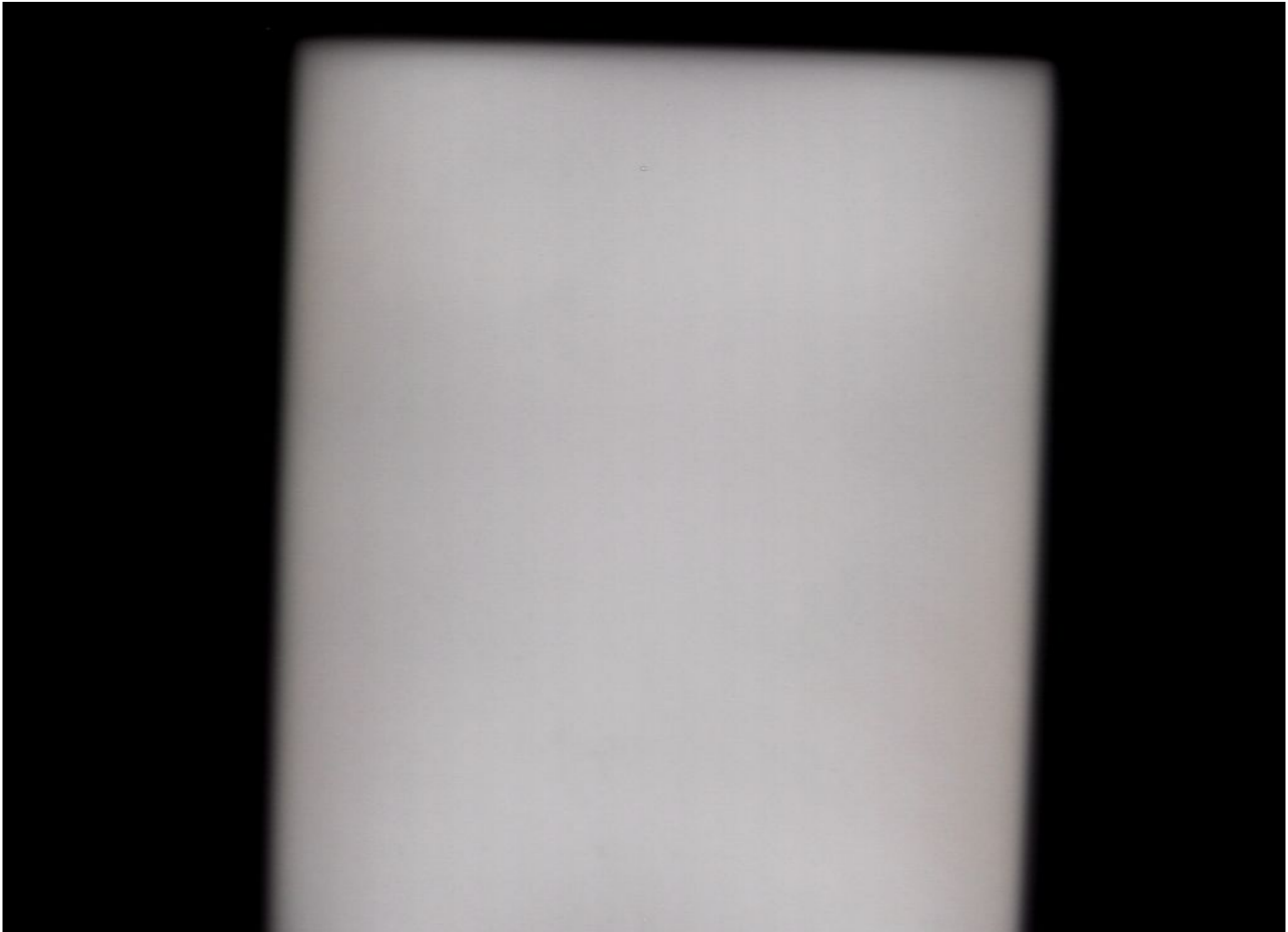
so we can find Ω by

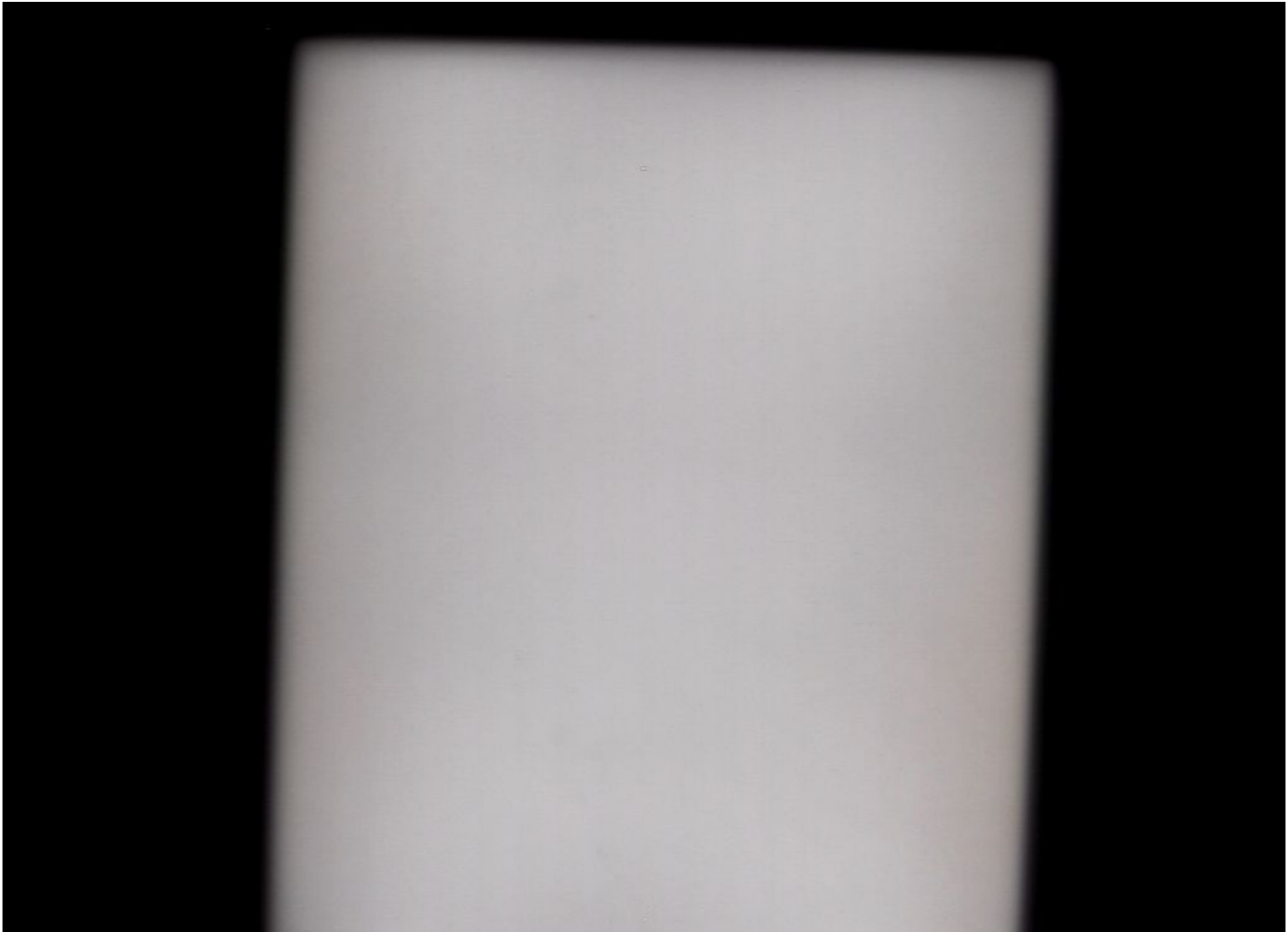
$$\Omega=\frac{\tfrac{1}{2}\nabla^a\Pi_a}{1-\Pi_b\Pi^b}$$

$$\Pi_a=\frac{\nabla_a\Omega}{\Omega^2-1}=\frac{\nabla_a(\Omega^{-1})}{\Omega^{-2}-1}$$

Note: If Ω were also a solution ($\tfrac{1}{2}\nabla_a\nabla^a\Omega^{-1}+\Omega^{-3}=0$), then $\Omega^{-1}=\frac{\tfrac{1}{2}\nabla^a\Pi_a}{1-\Pi_b\Pi^b}$

also, so $\Pi_b\Pi^b=0=\nabla^a\Pi_a$, which is indeed [illegible] true [illegible] cross-over [illegible] everywhere else.





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

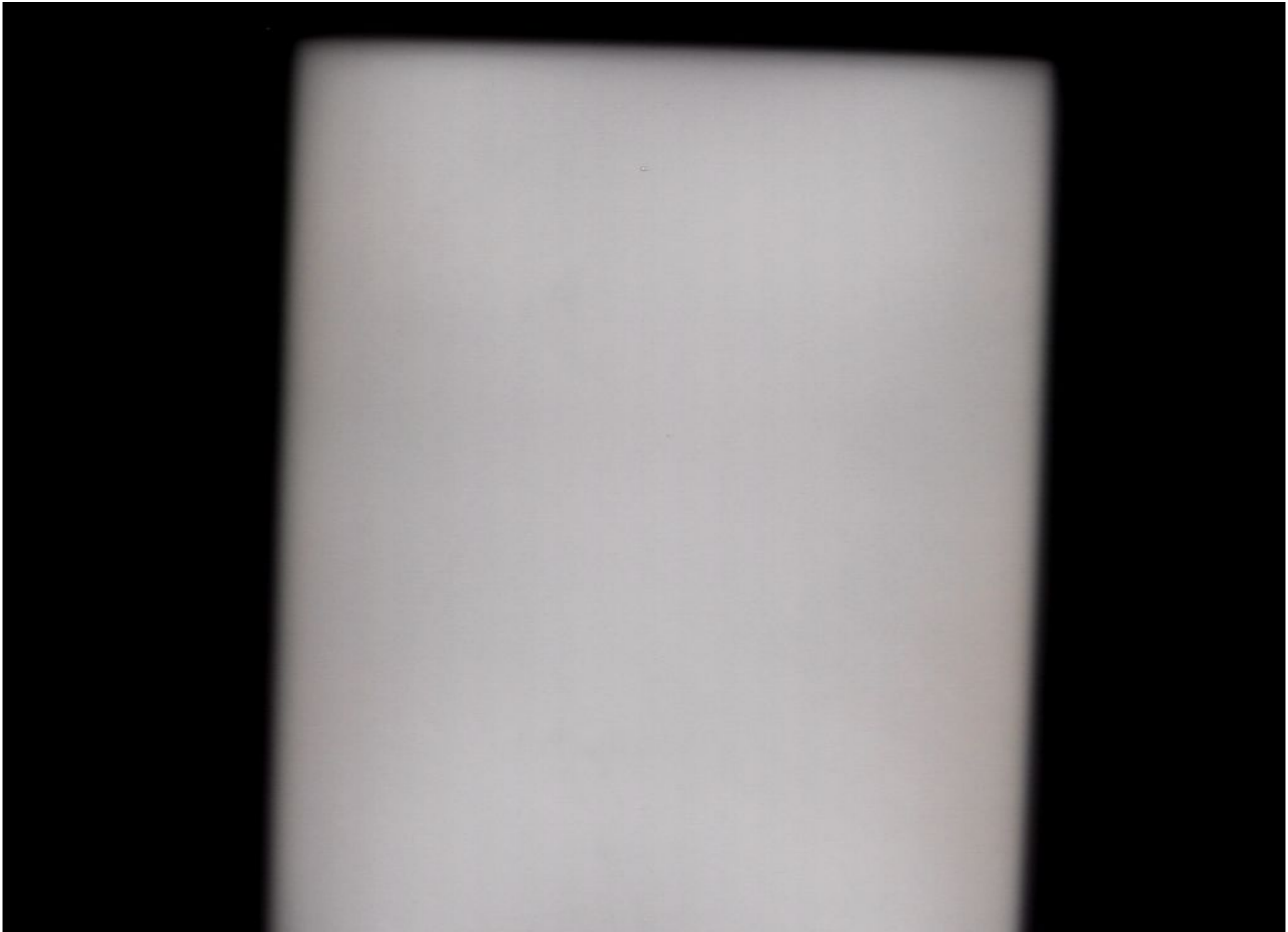
Reciprocal hypothesis:

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

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 $\check{R} = 4\Lambda + 8\pi G\mu$

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.":

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



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

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

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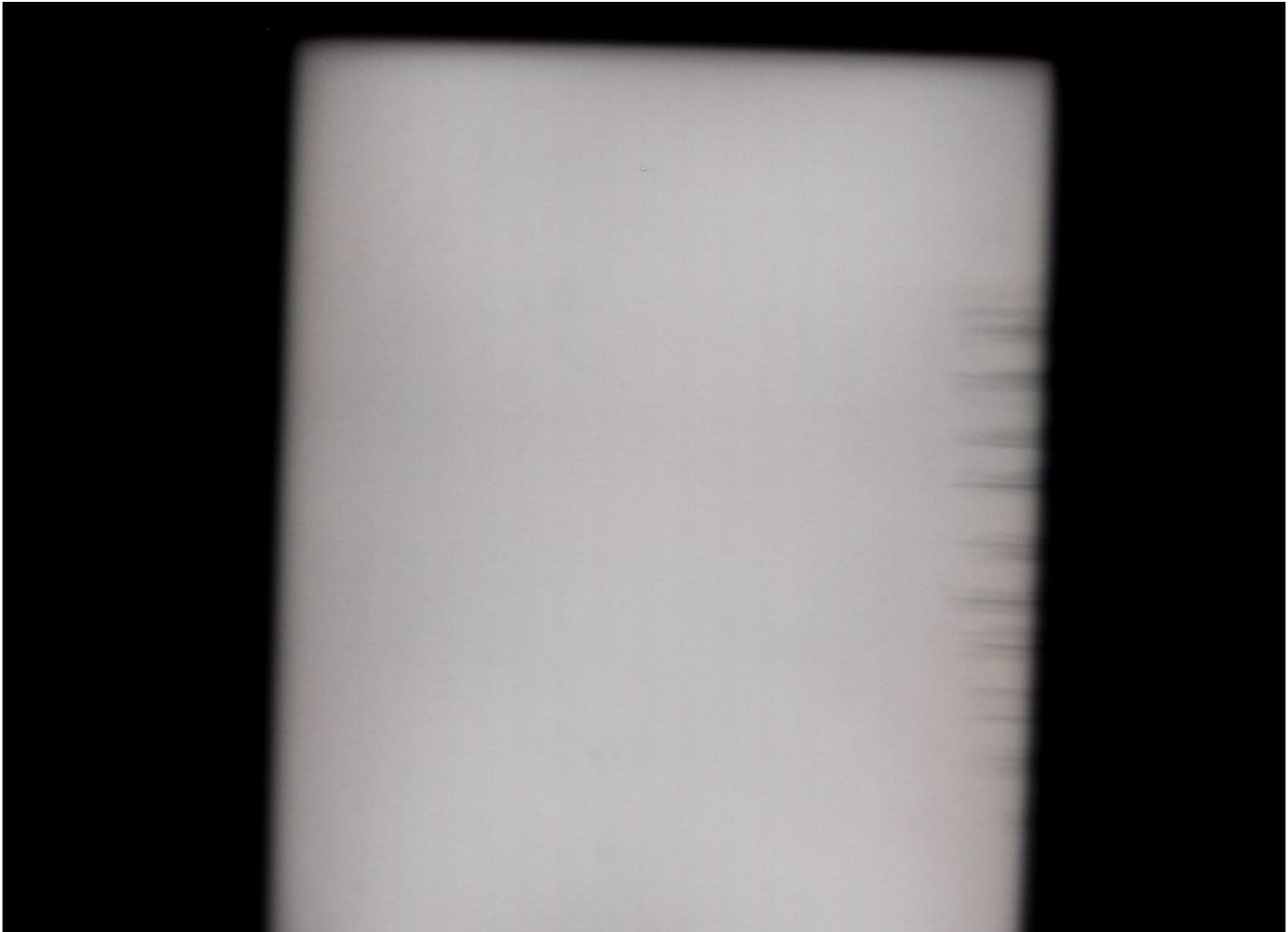

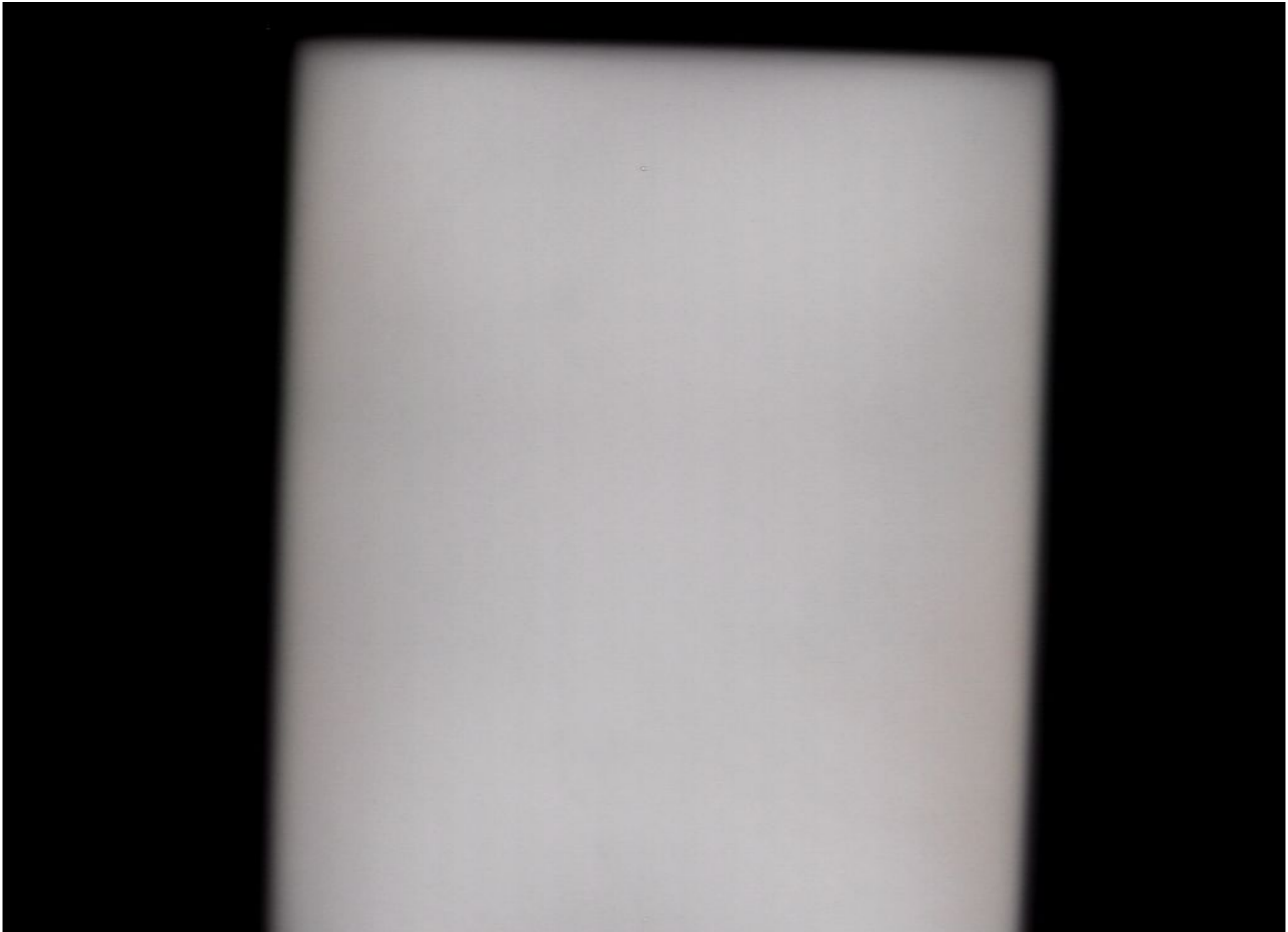

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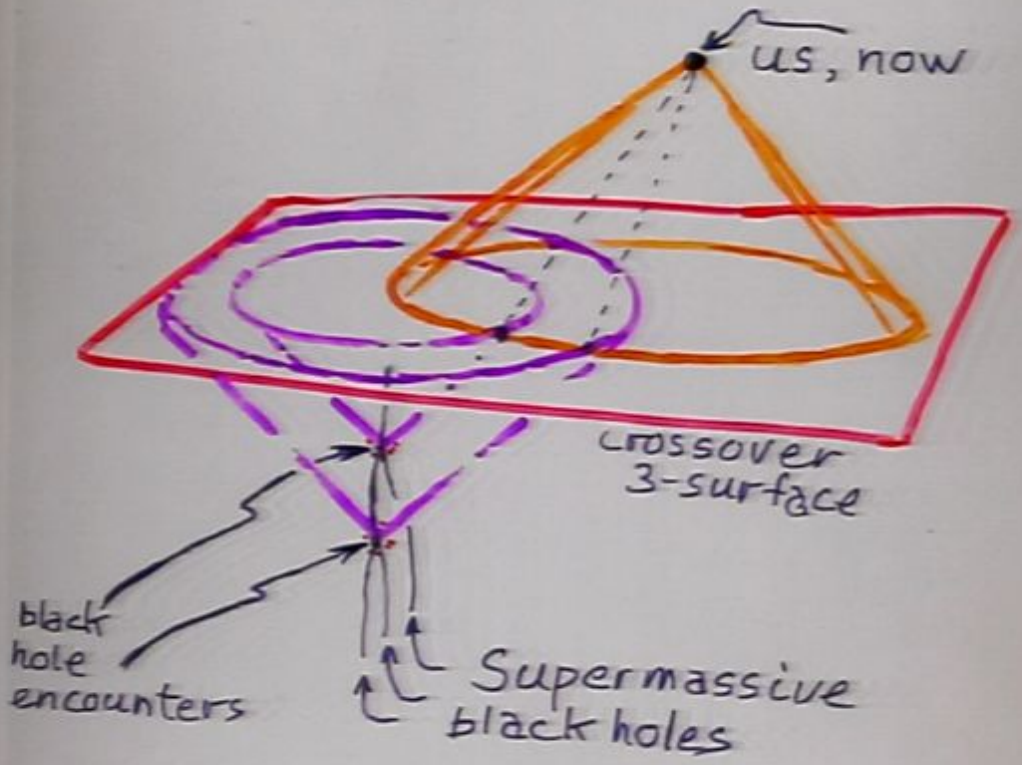
Can we "see" through into the aeon prior to ours?



- Anomalous temperature
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V. Gurzadyan

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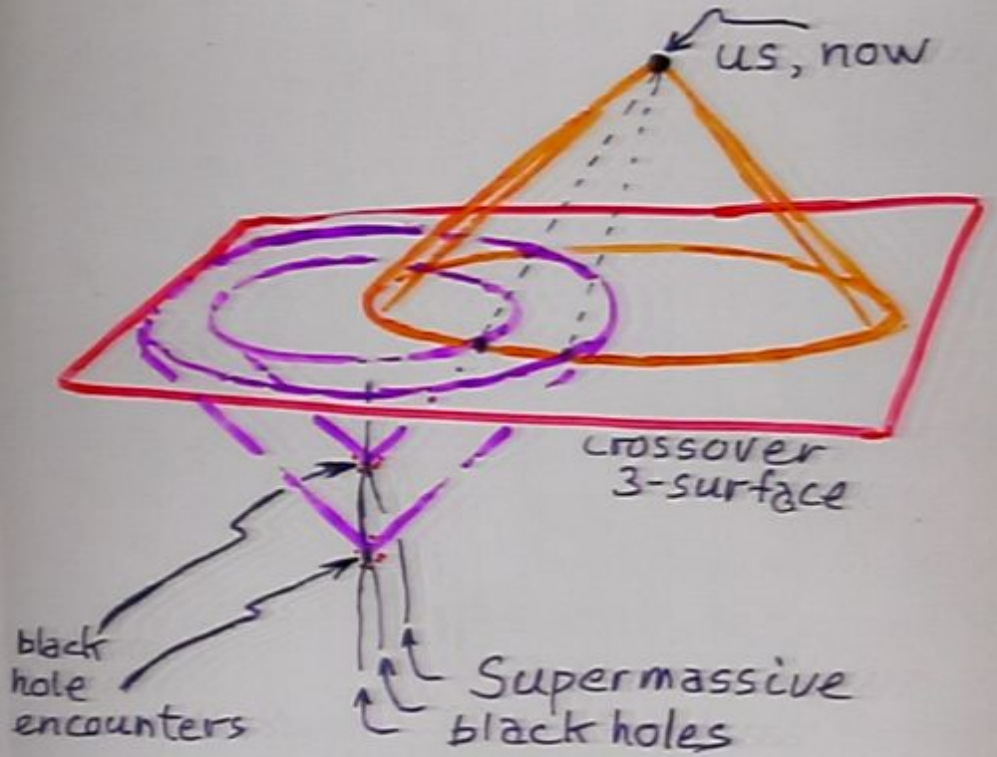

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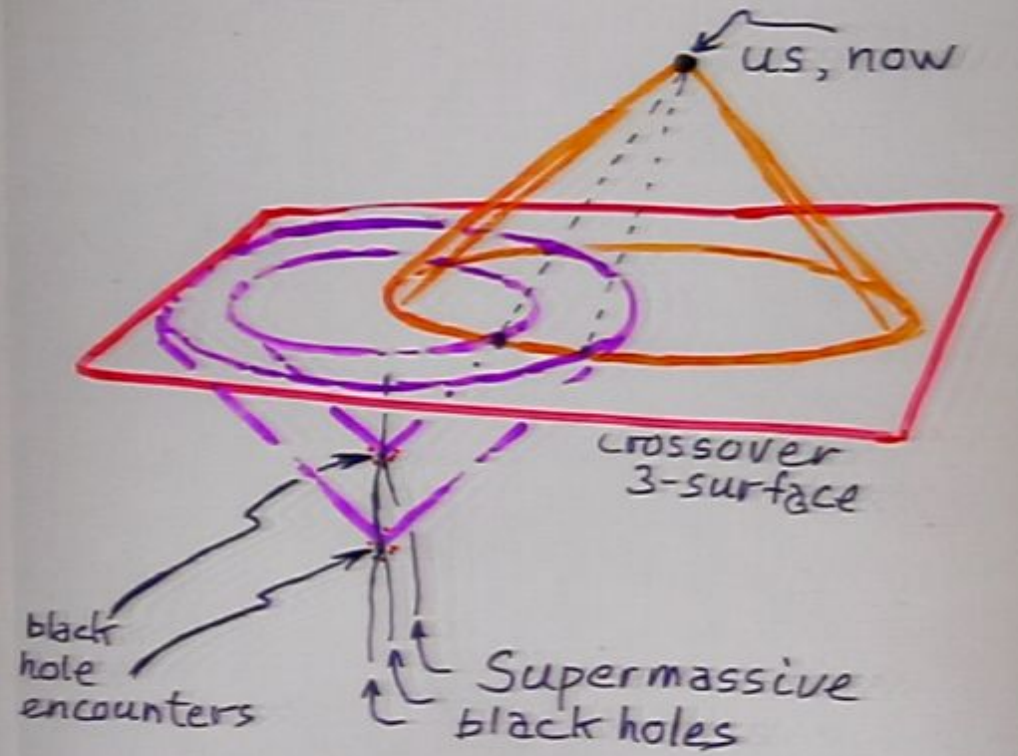
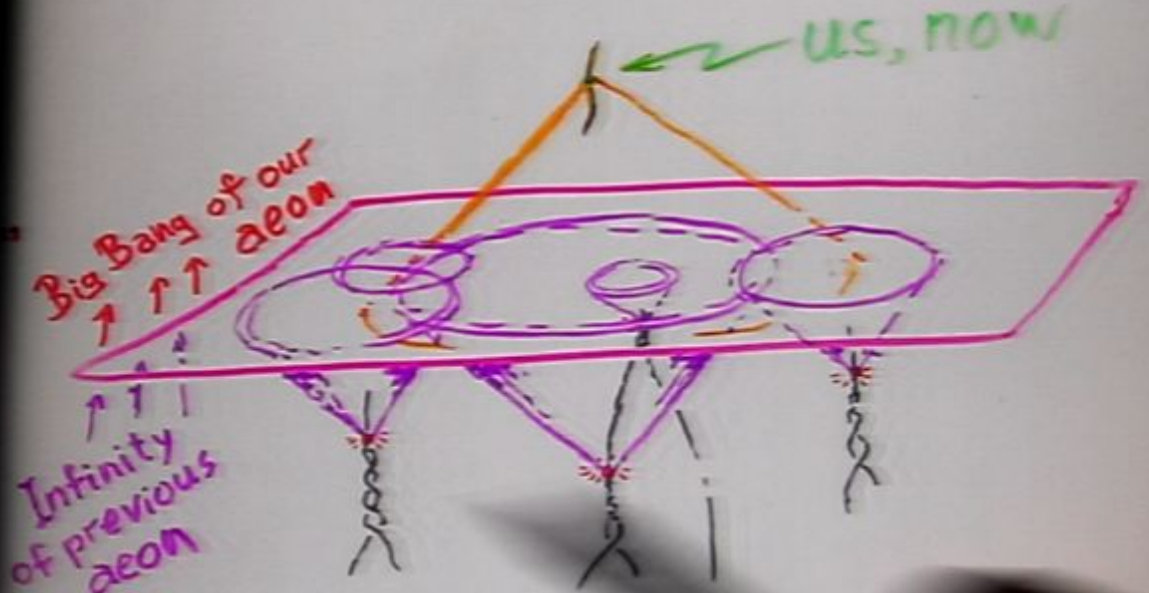




Observational consequence concerning temperature/density variations in Cosmic Microwave Background



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Pattern of ripples looks random at first, but can be analysed into circles

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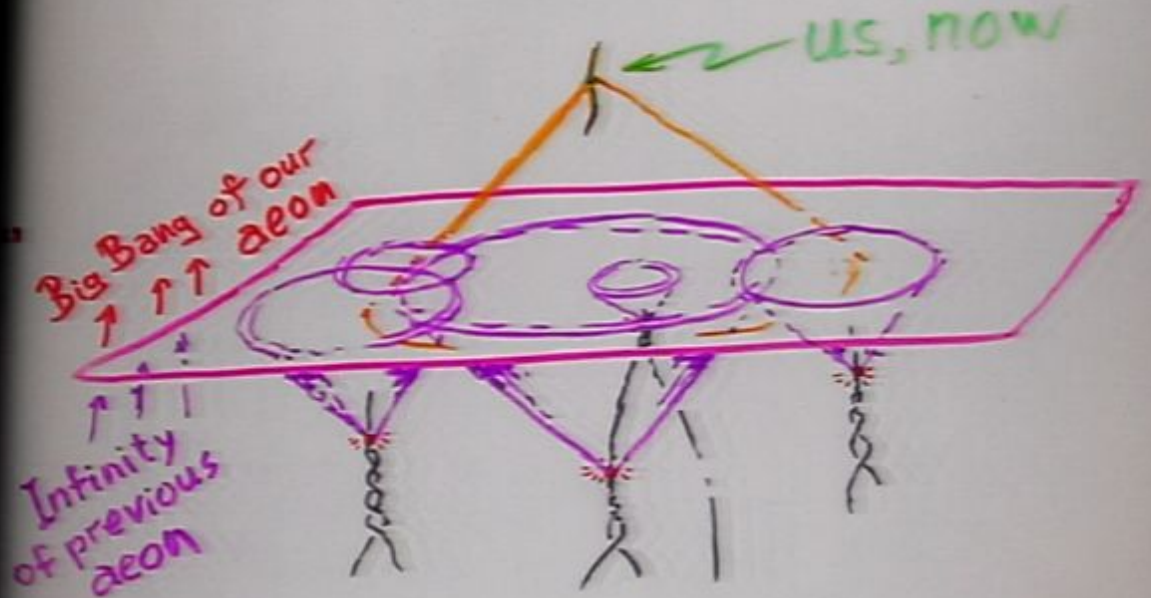

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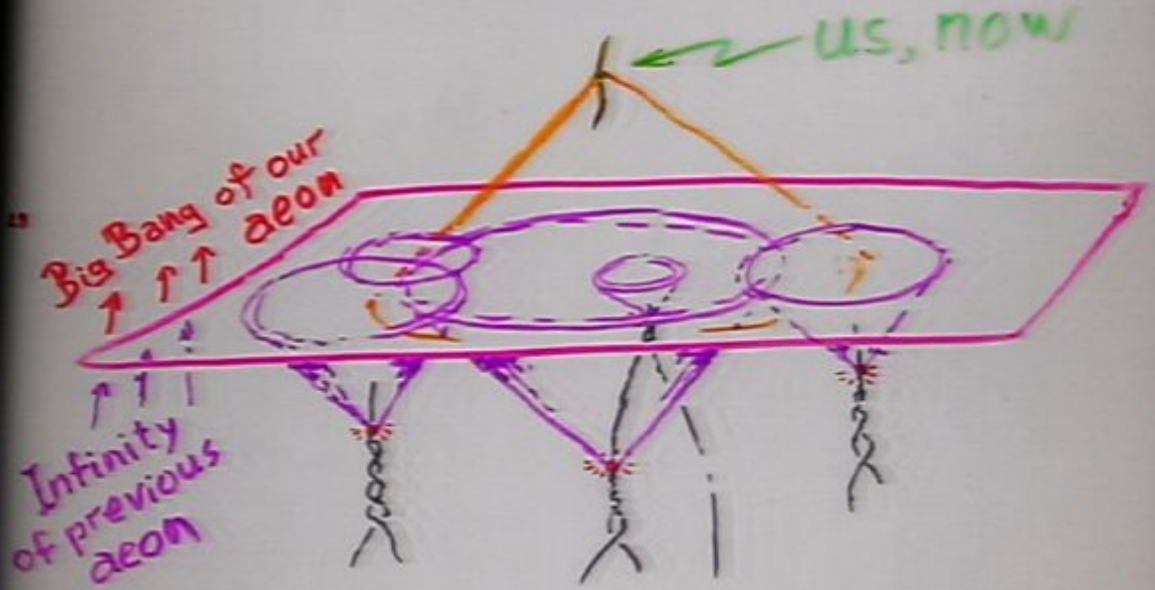

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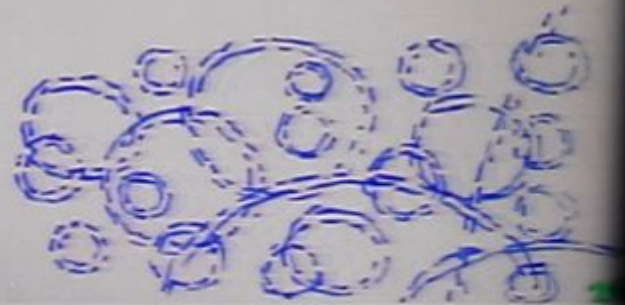

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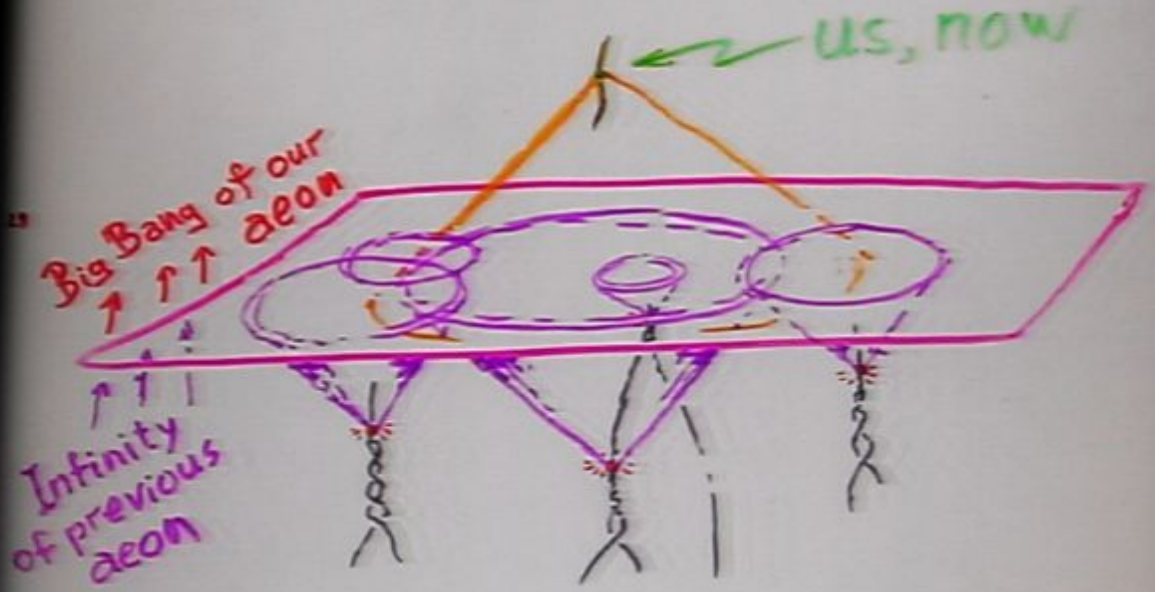

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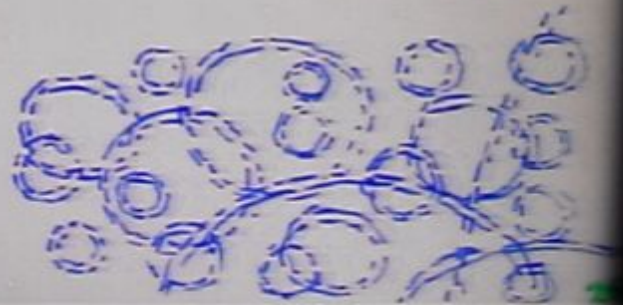

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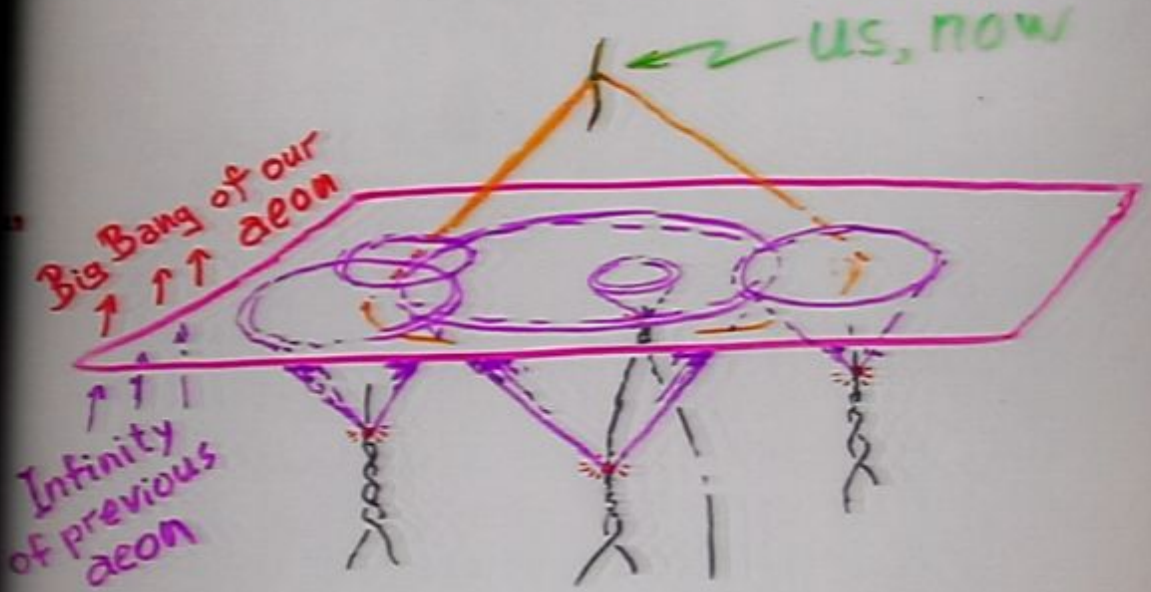

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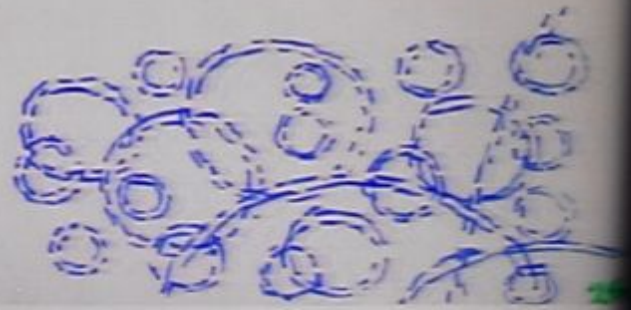



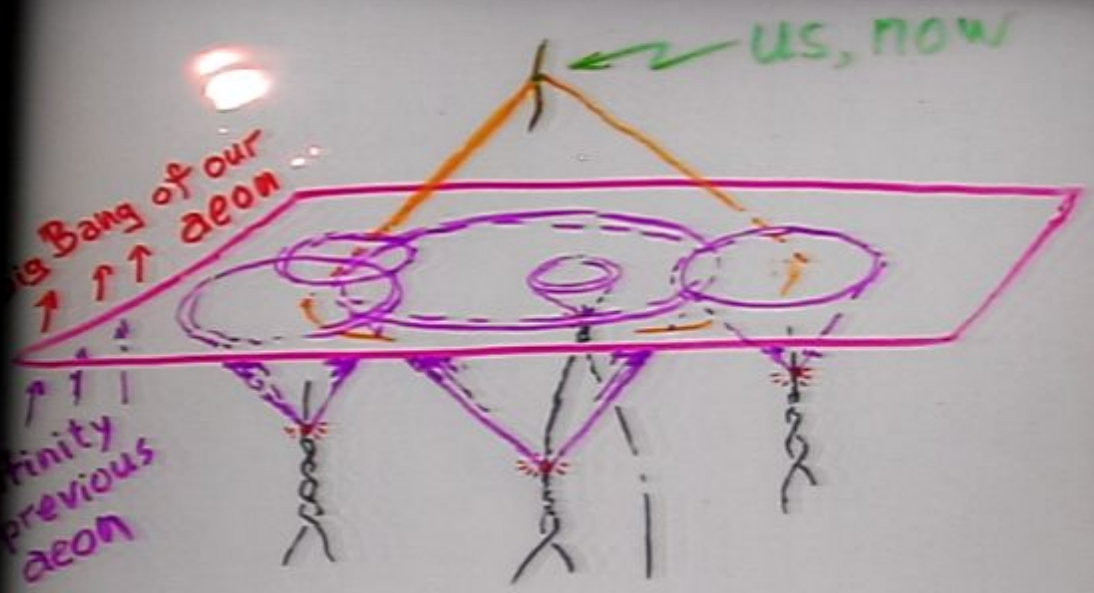

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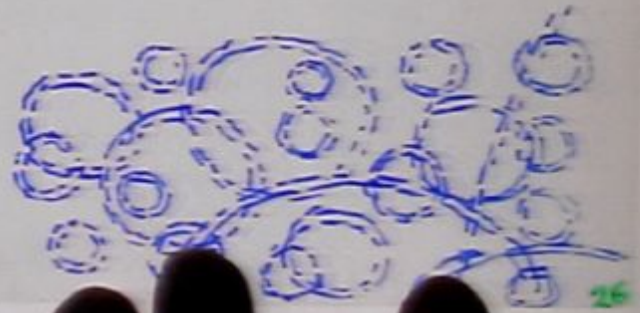

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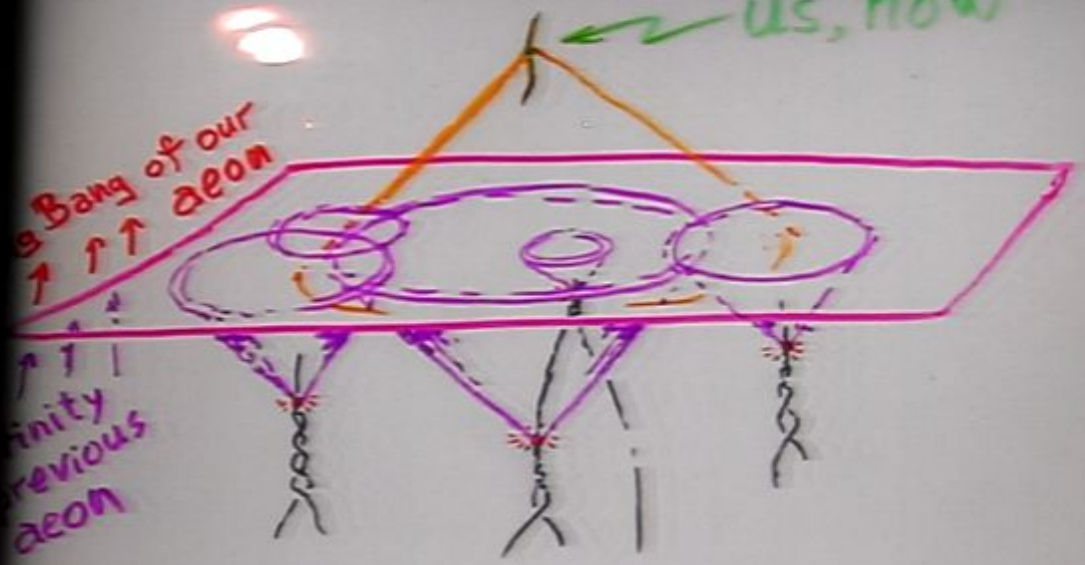

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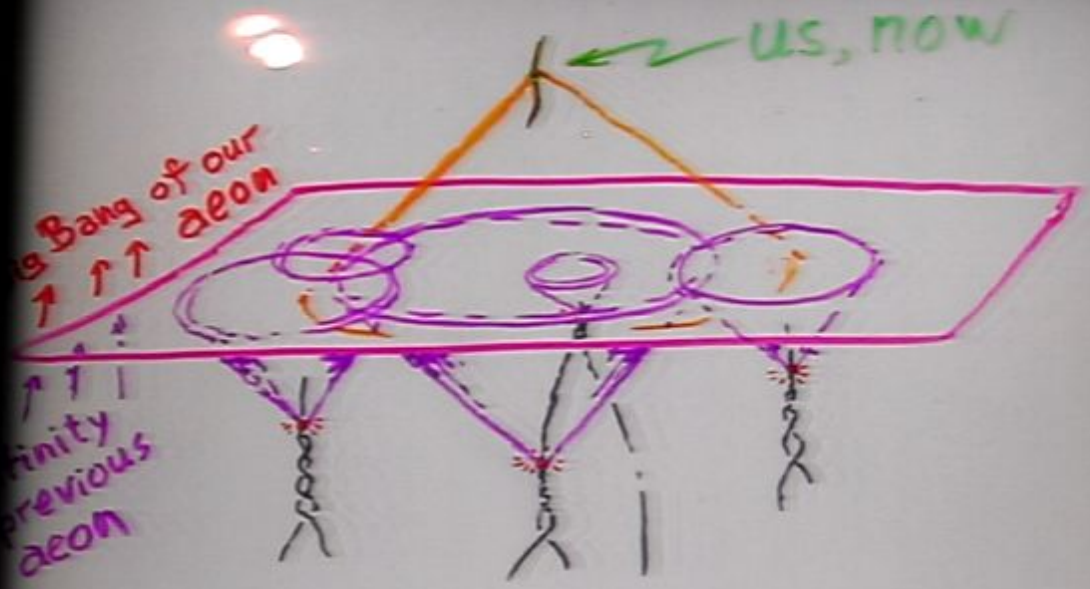

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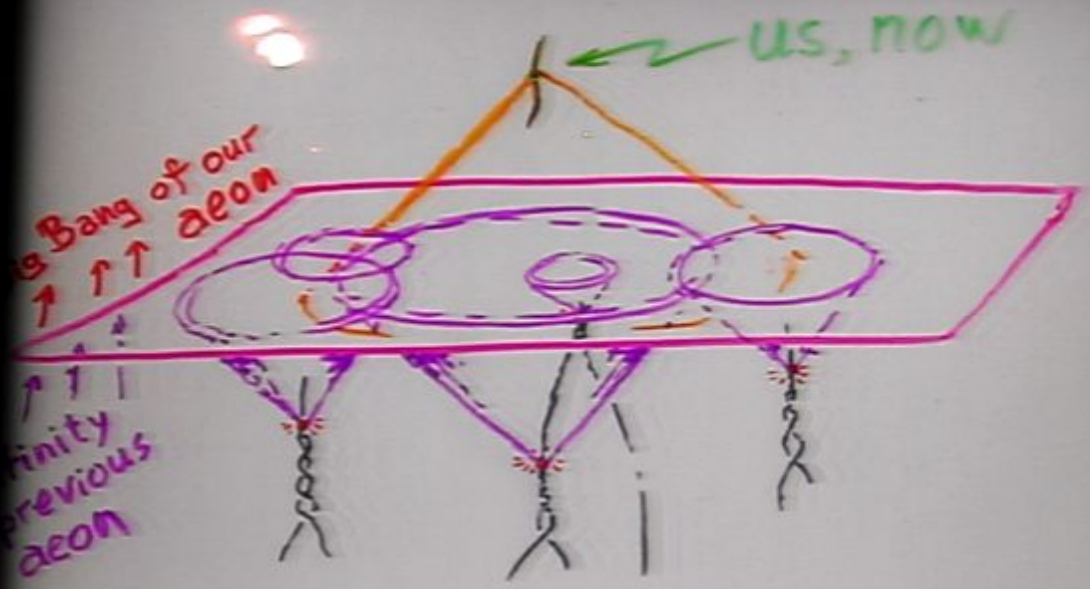

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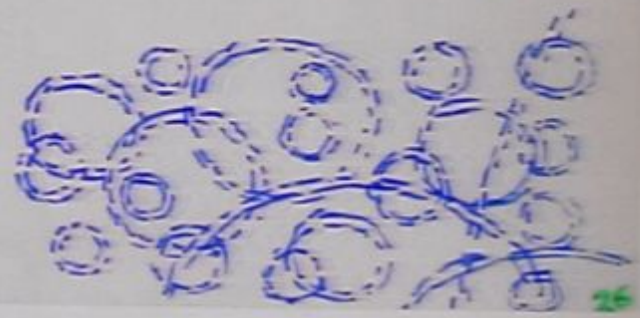

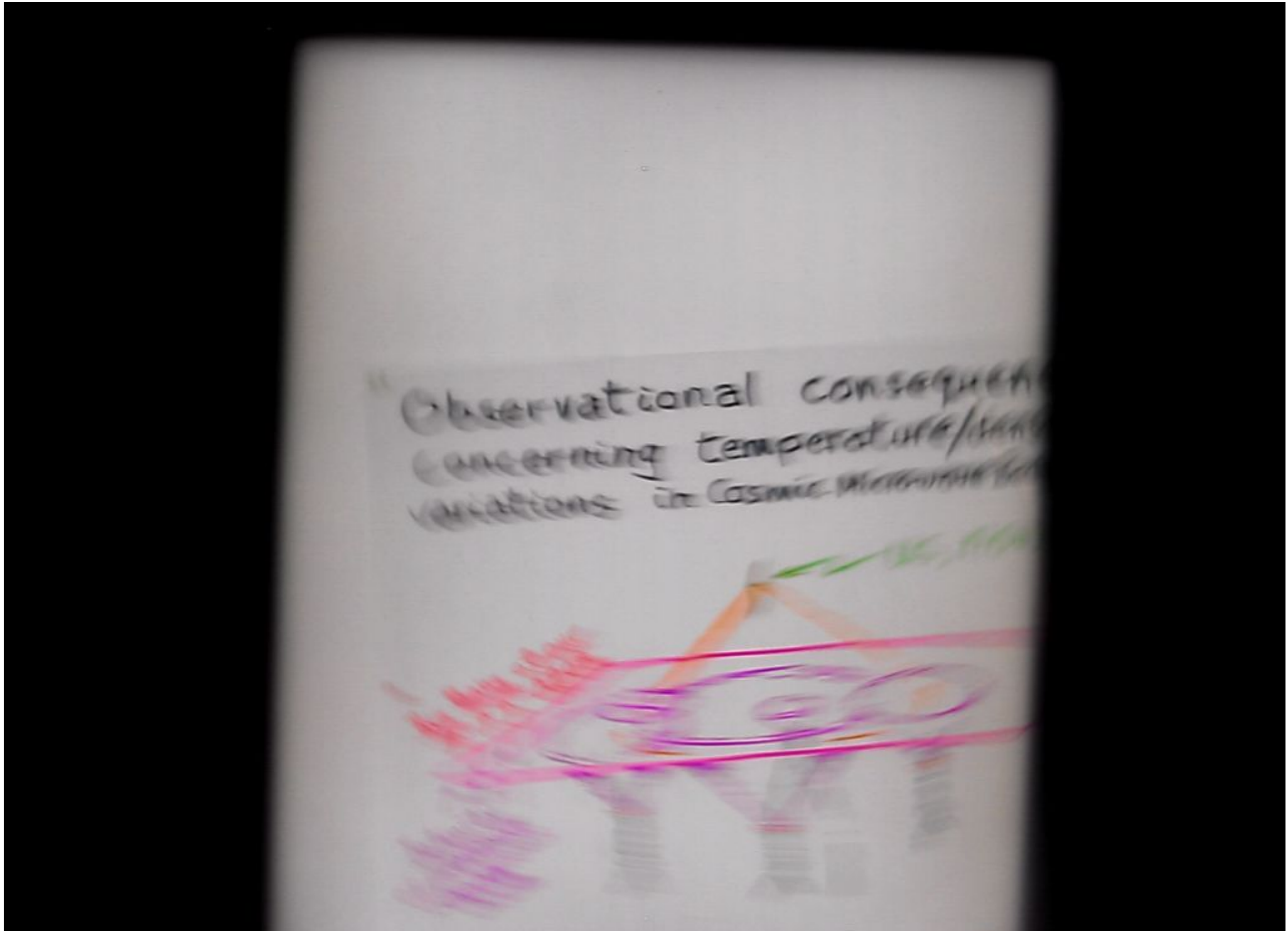
Observational
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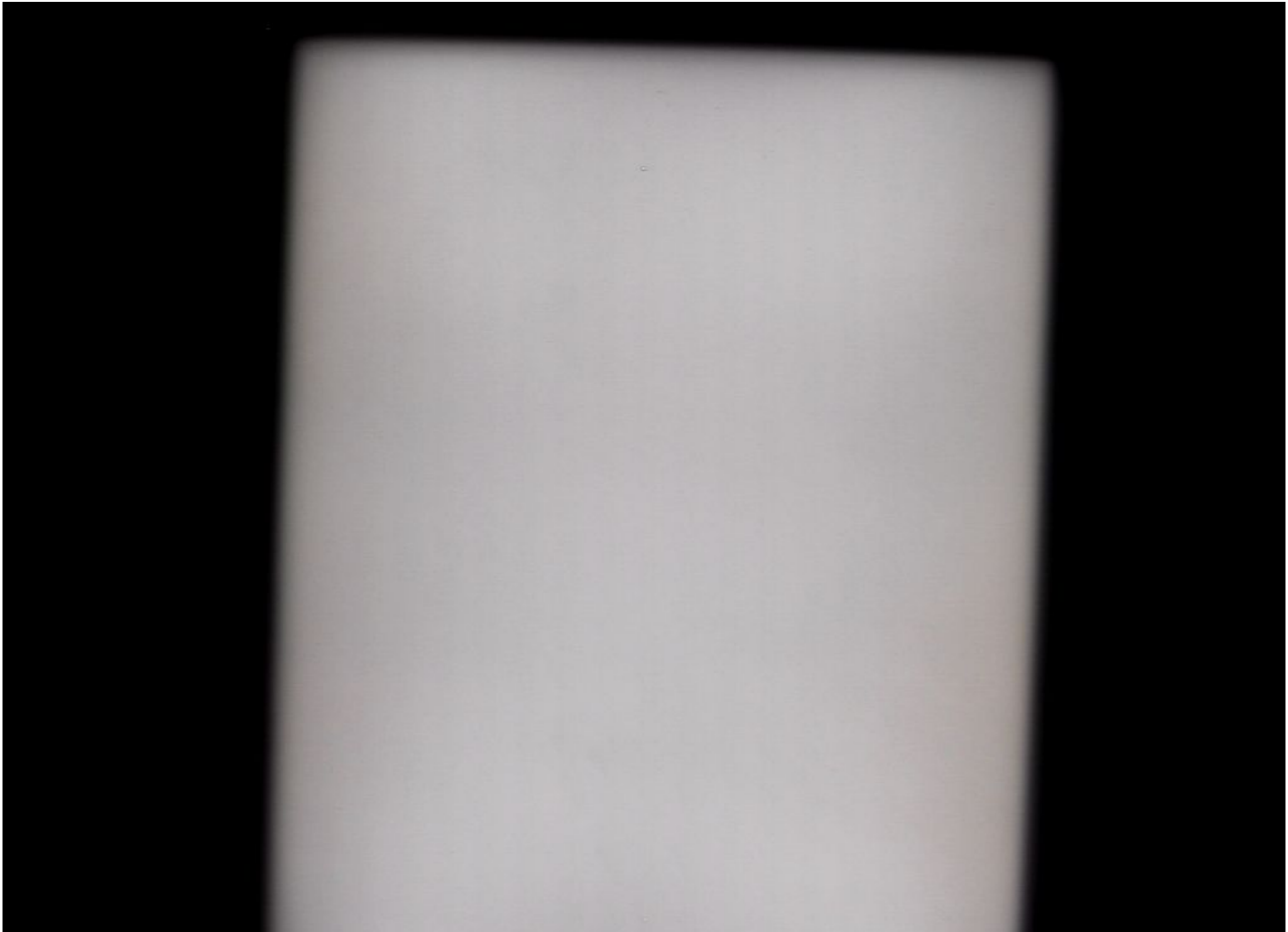



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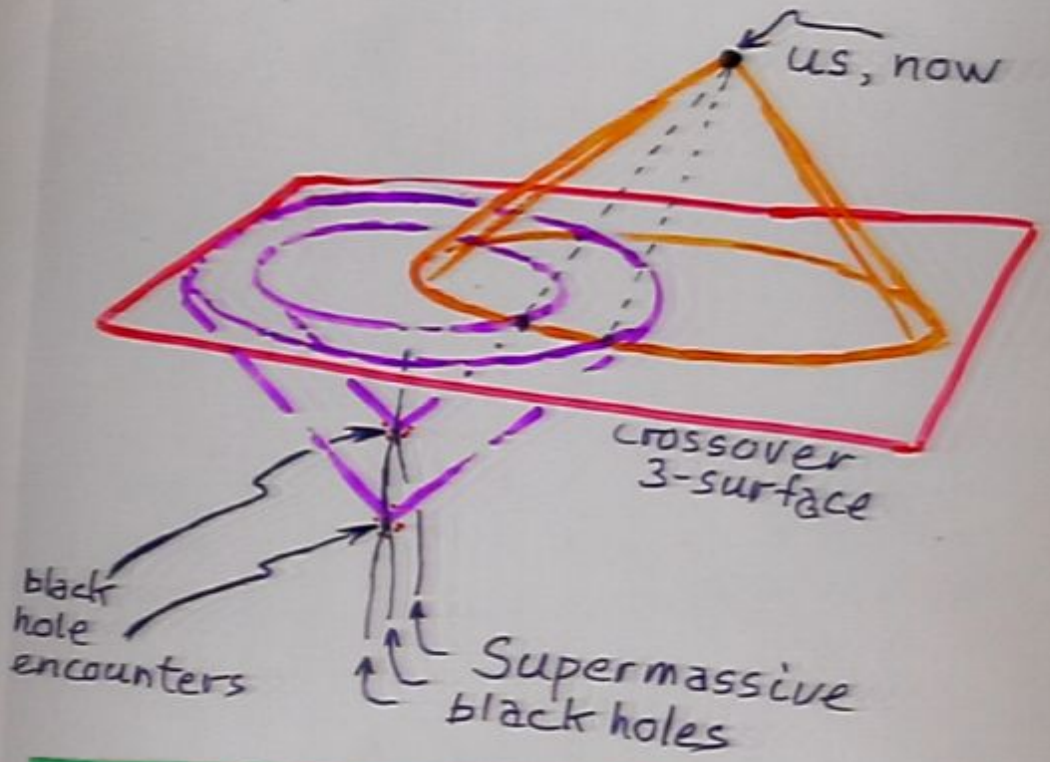

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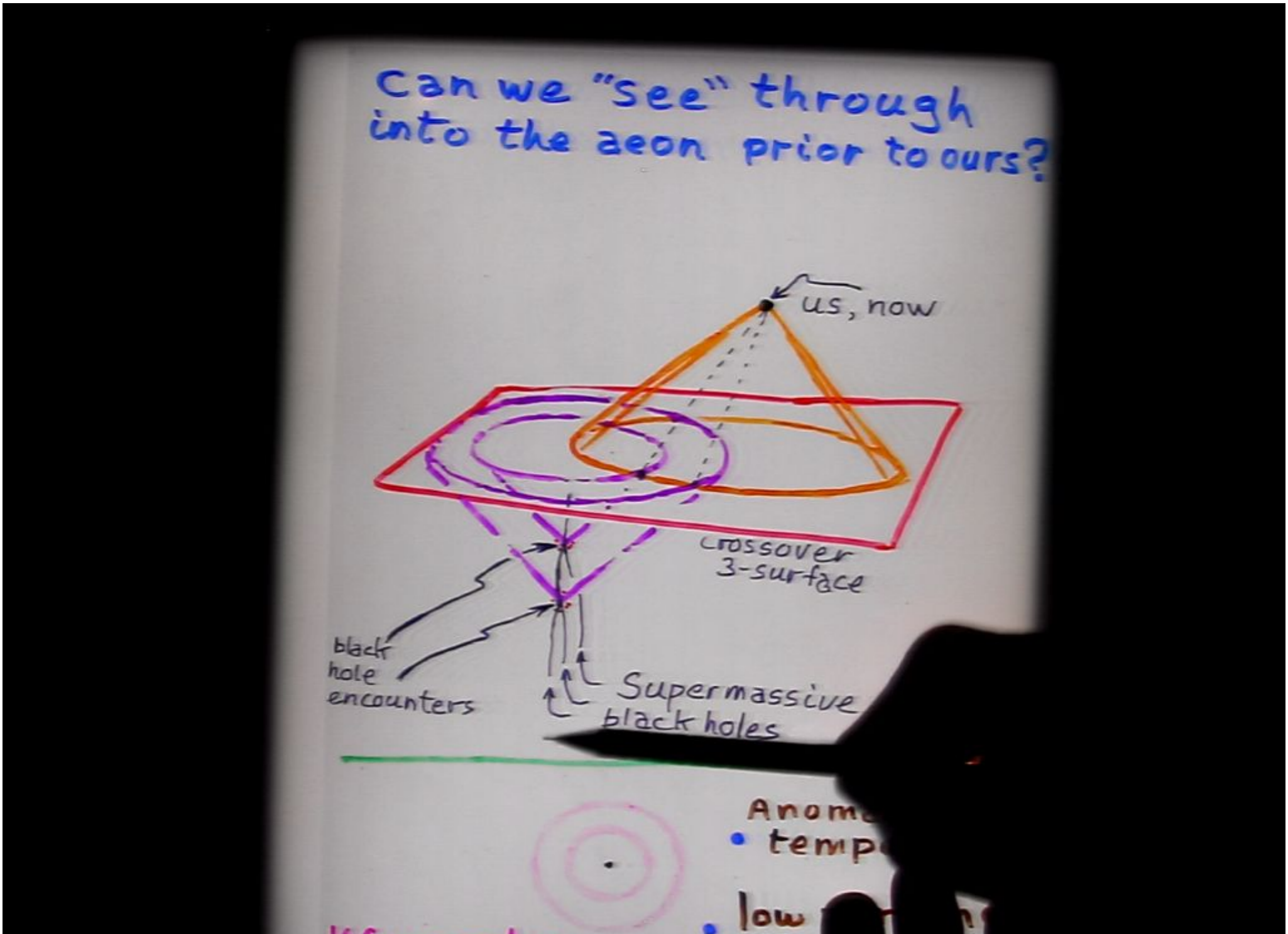
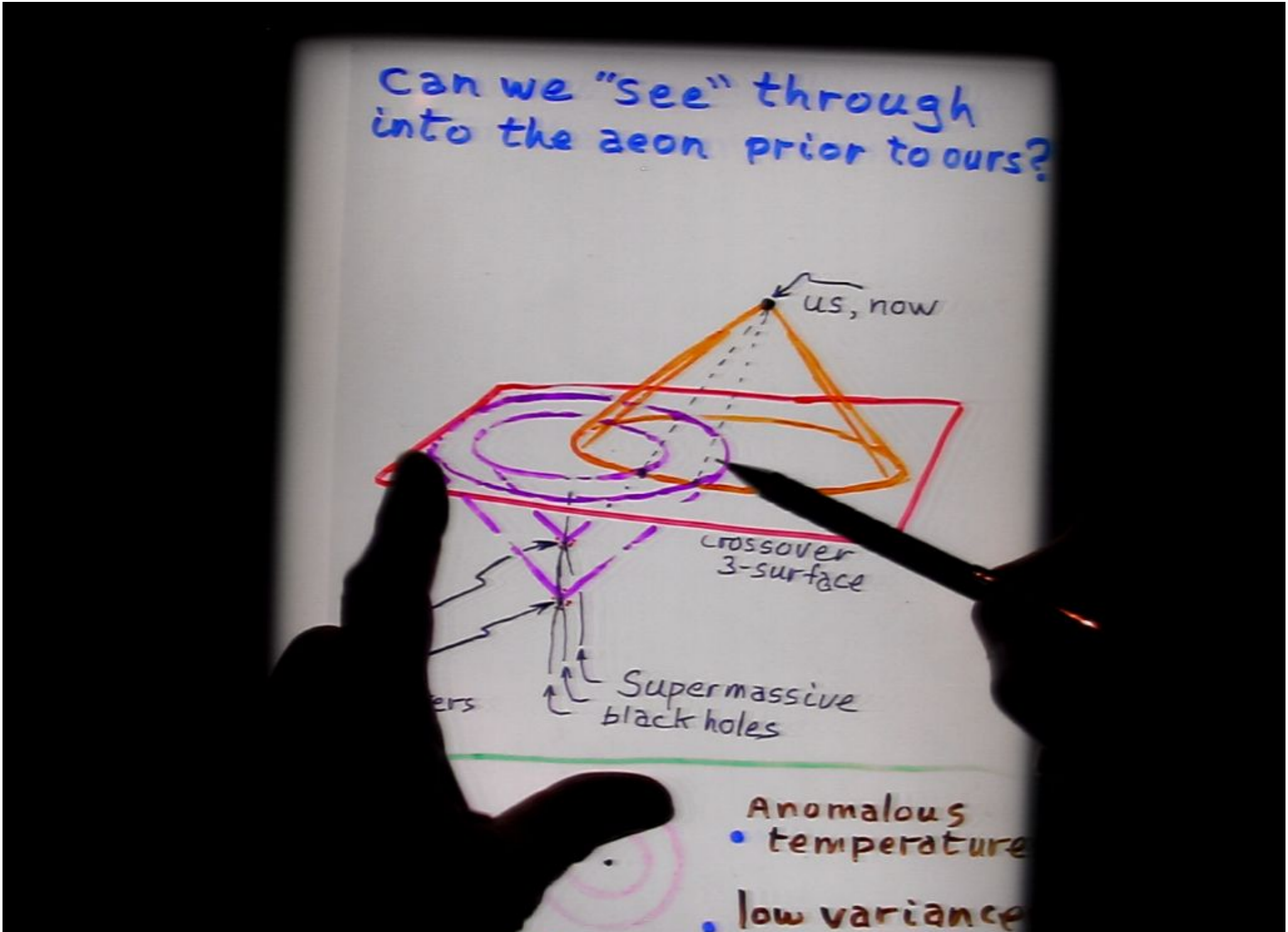

Can we "see" through into the aeon prior to ours?
us, now
crossover 3-surface
black hole encounters
Supermassive black holes
Anom
temp
low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Supermassive black holes
Anomalous
• temperature
• low variance

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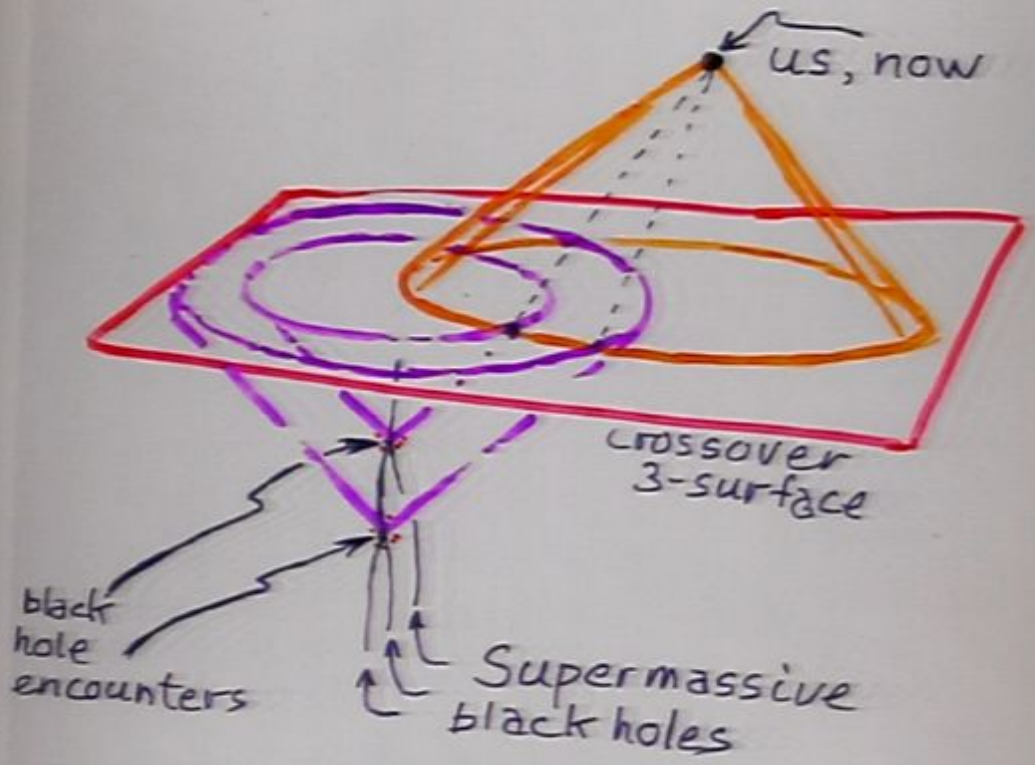

- Anomalous temperature
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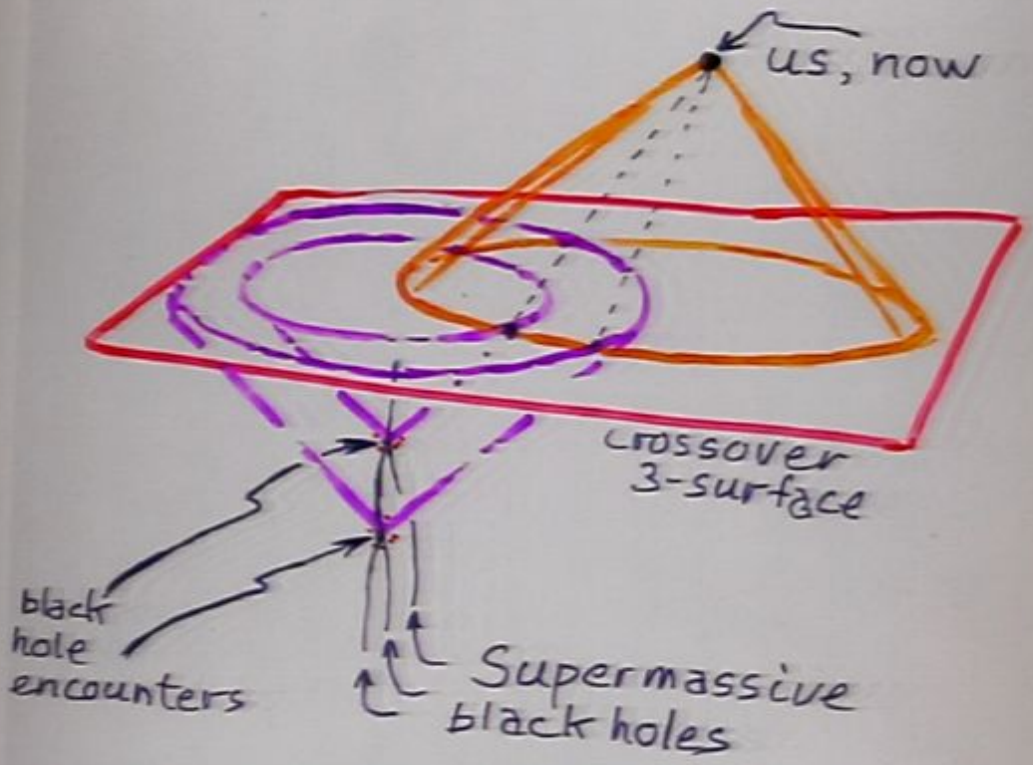

- Anomalous temperature
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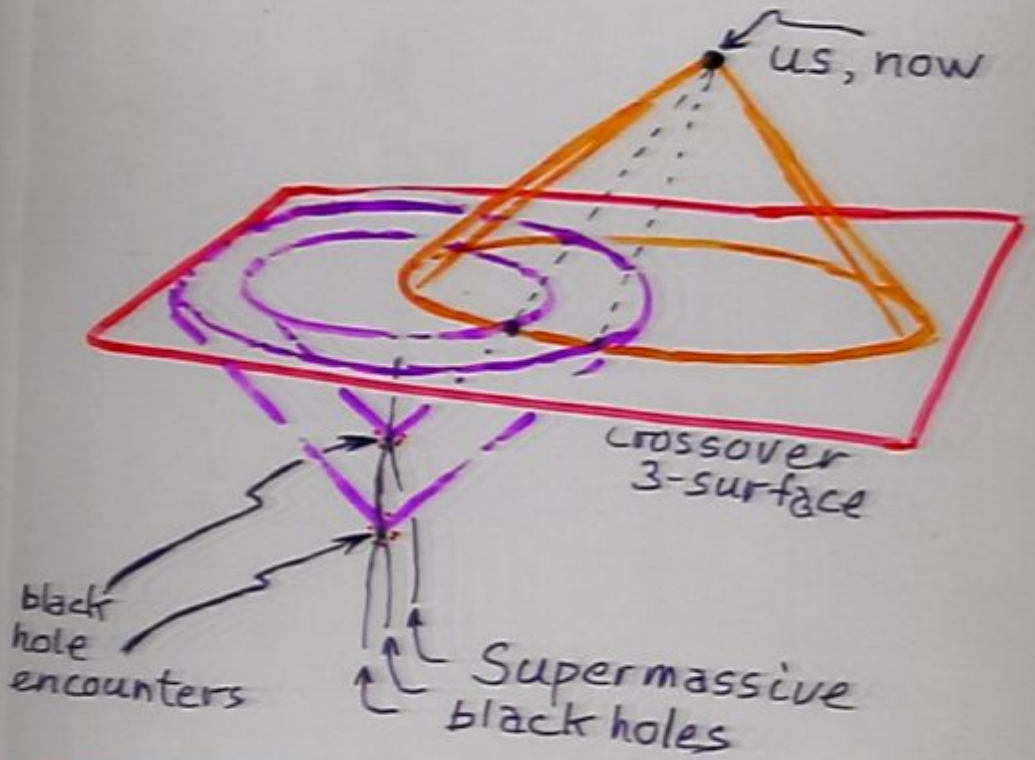
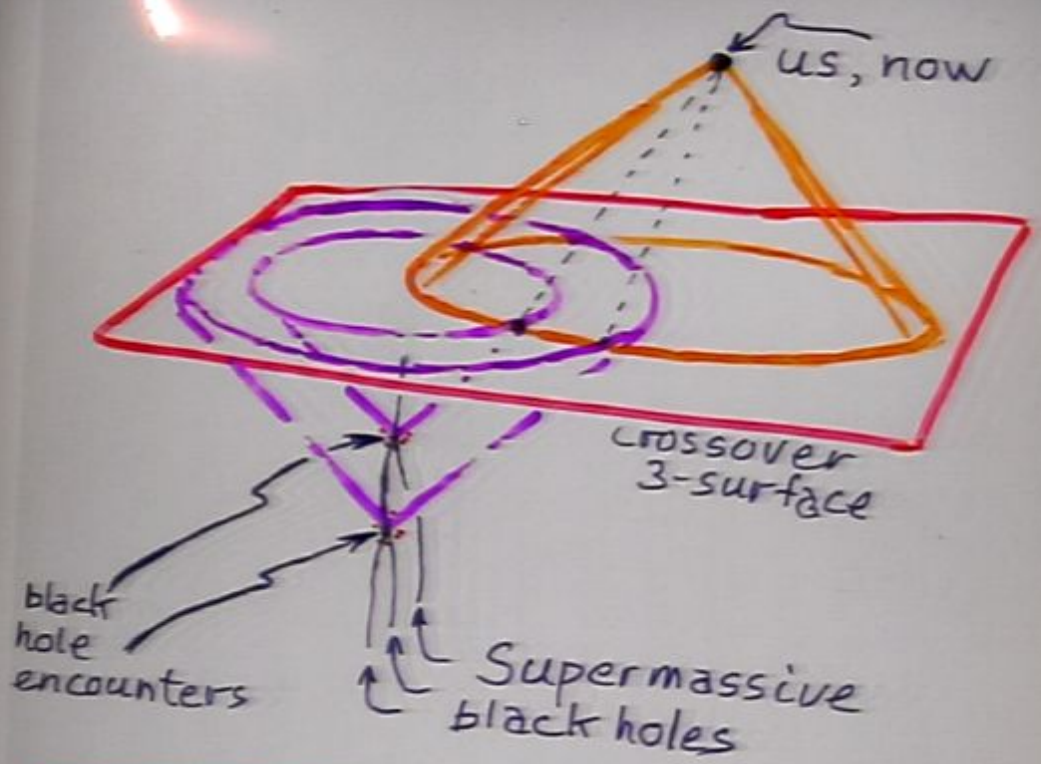


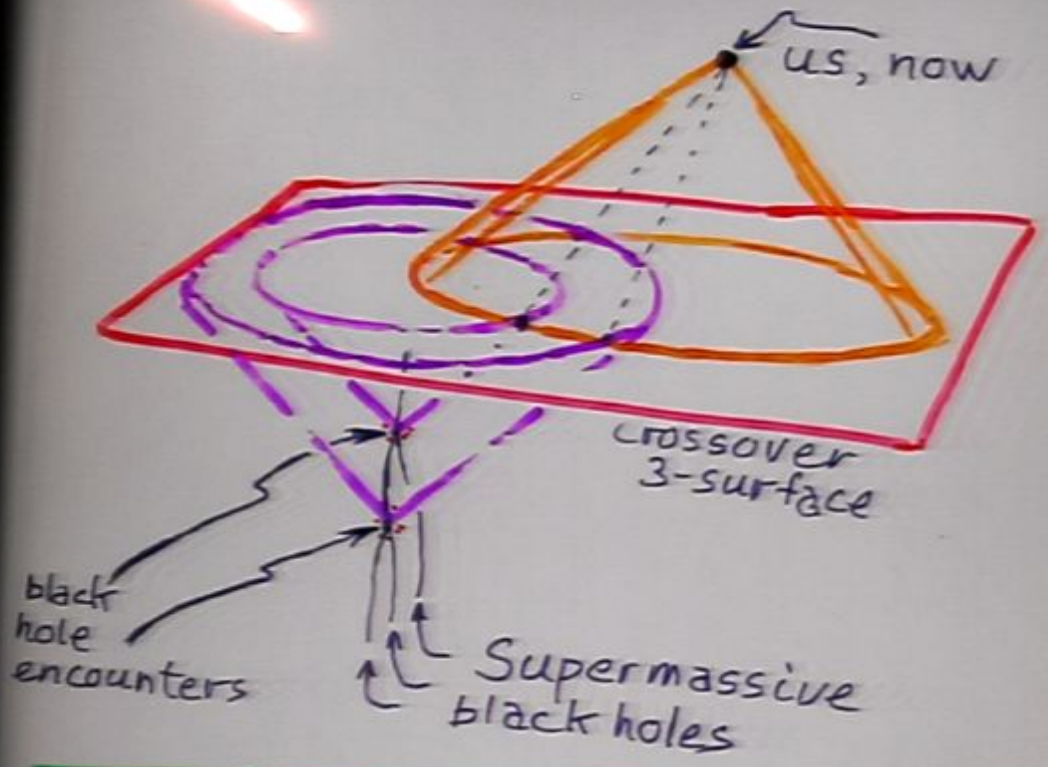
- Anomalous temperature
- low variance





- Anomalous temperature
- low variance concentric rings

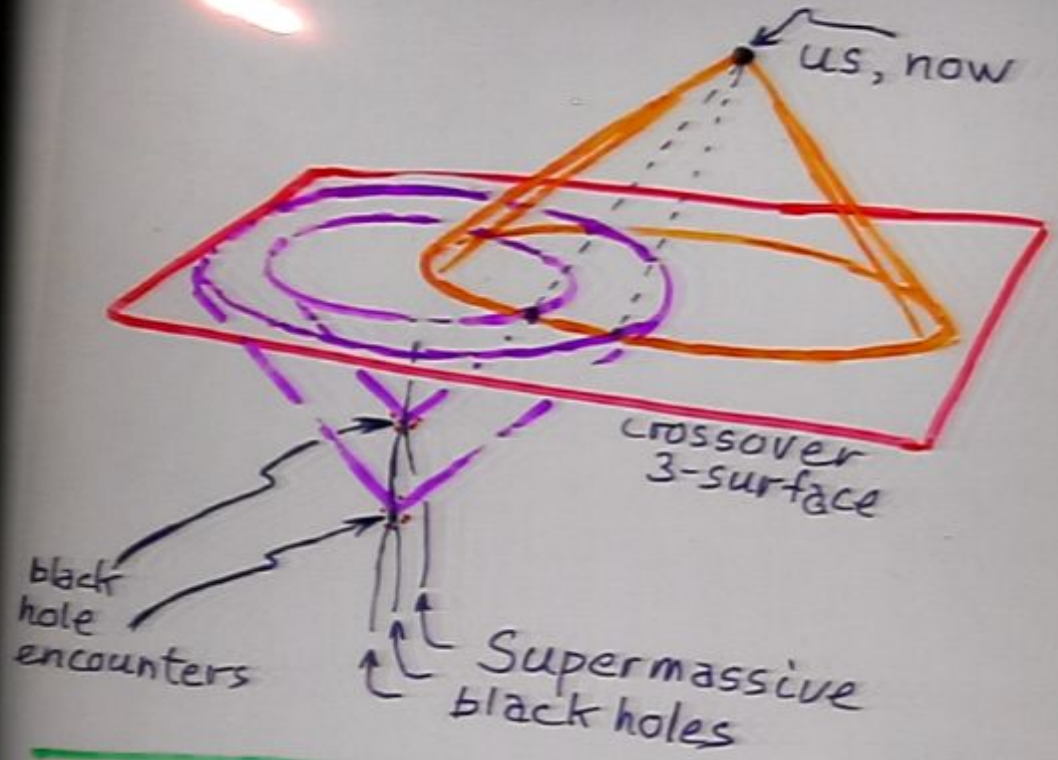
V. Gurzadyan





- Anomalous temperature
- low variance concentric rings

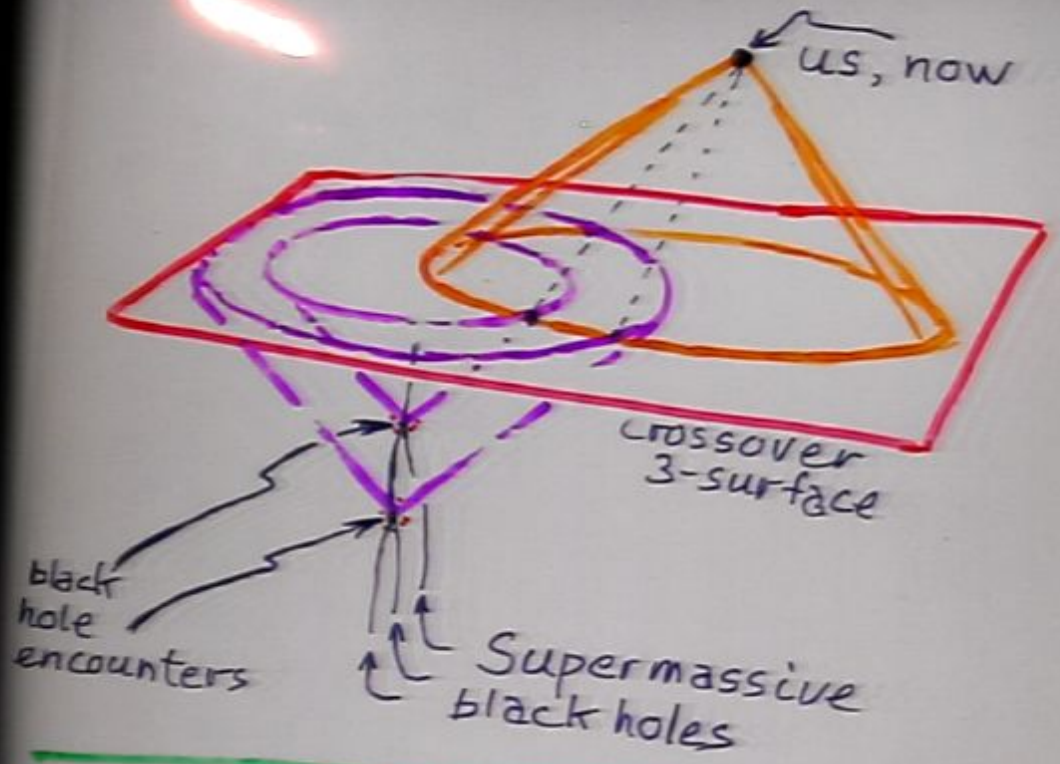
V. Gurzadyan





- Anomalous temperature
- low variance concentric rings

V. Gurzadyan



- Anomalous temperature
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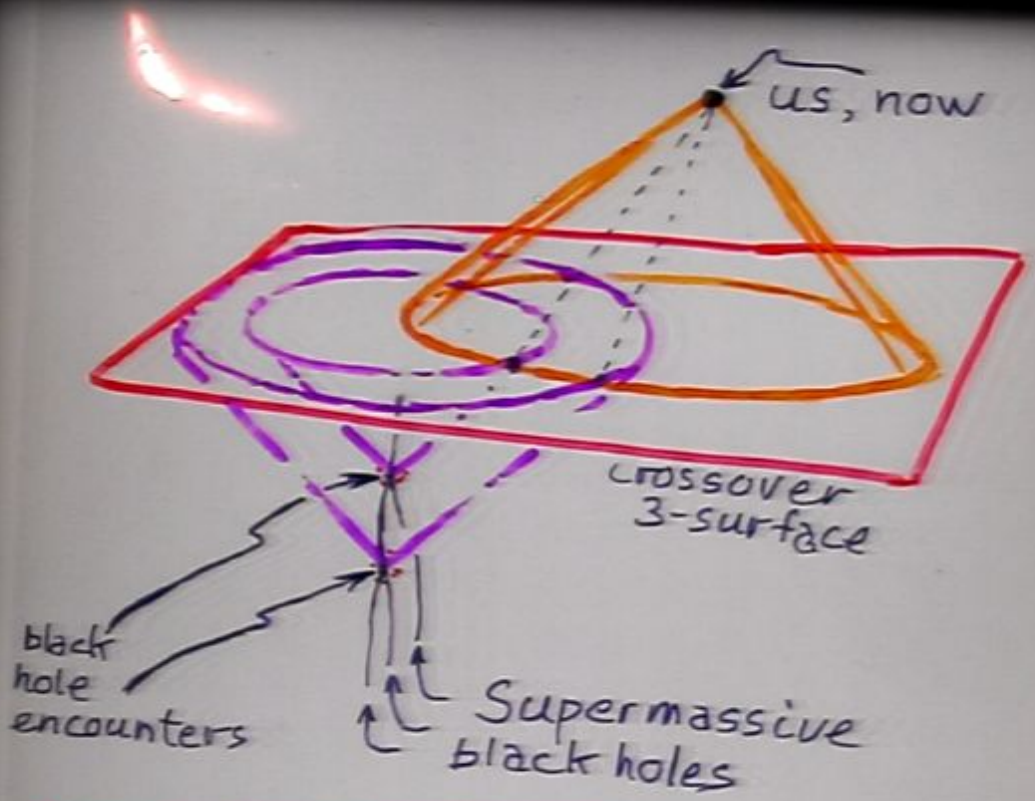
V. Gurzadyan



- Anomalous temperature
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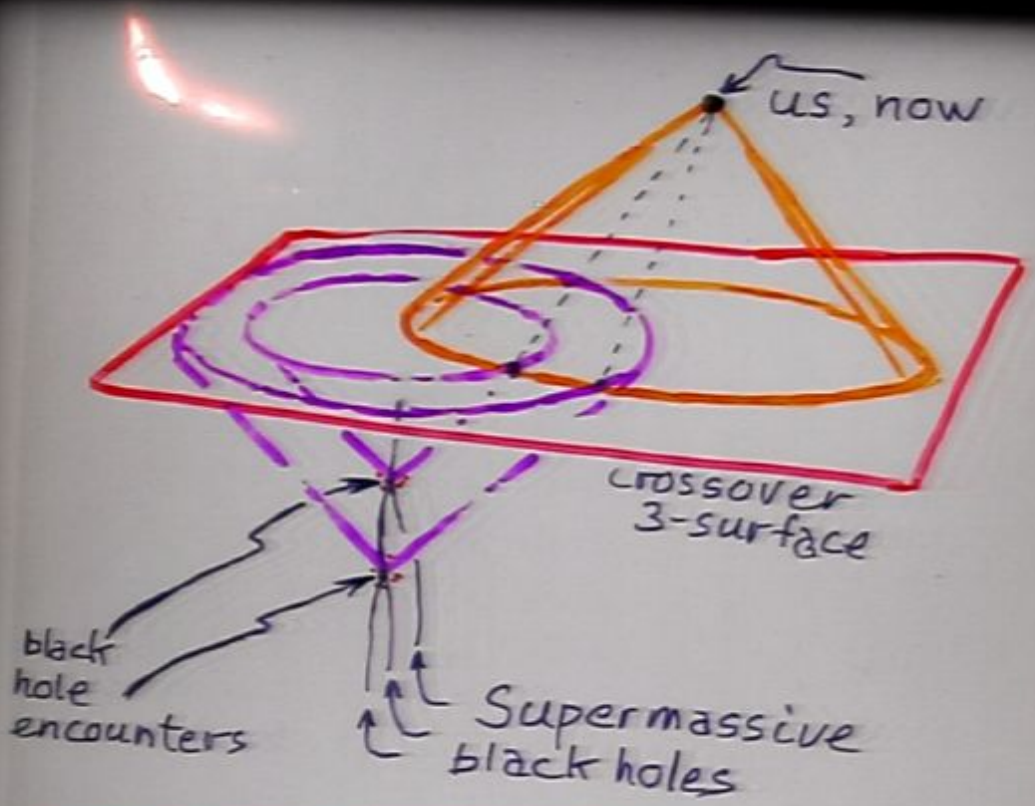
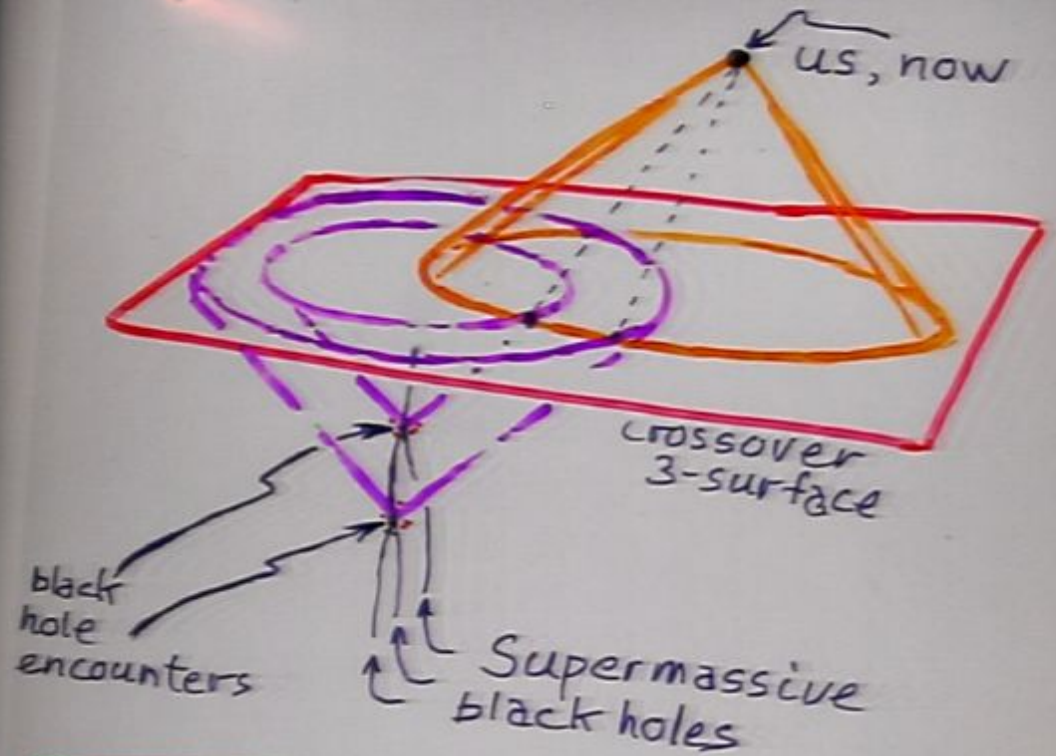




- Anomalous temperature
- low variance concentric rings

V. Gurzadyan





V. Gurzadyan

- Anomalous temperature
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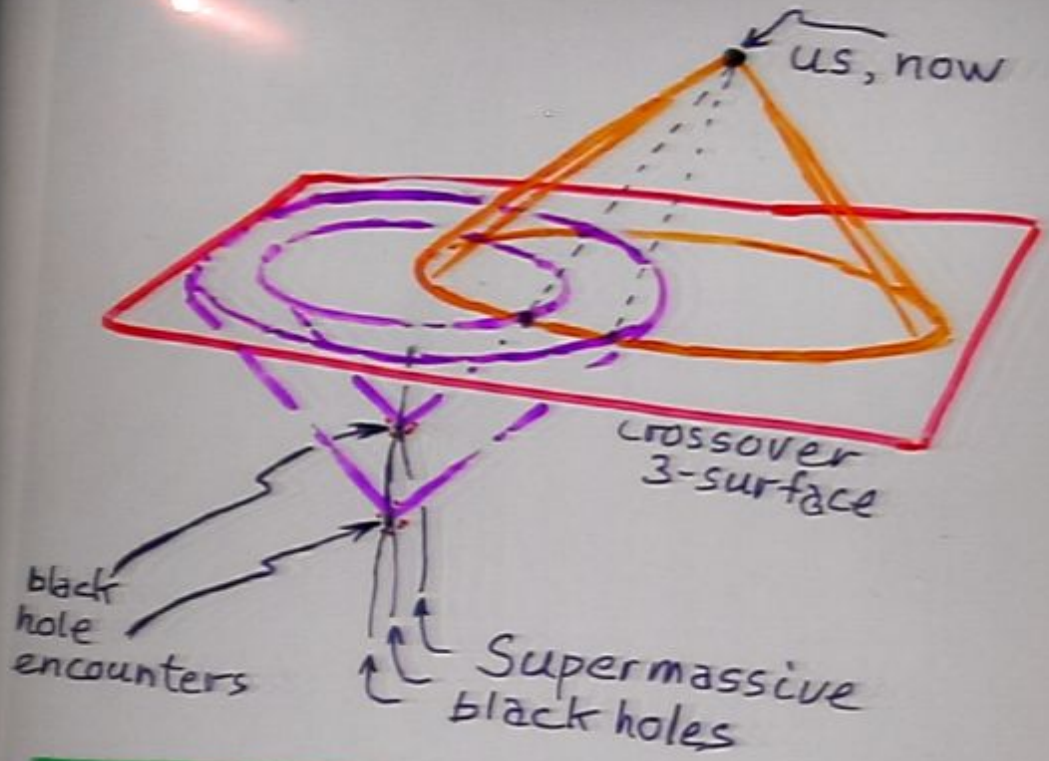



V. Gurzadyan

- Anomalous temperature
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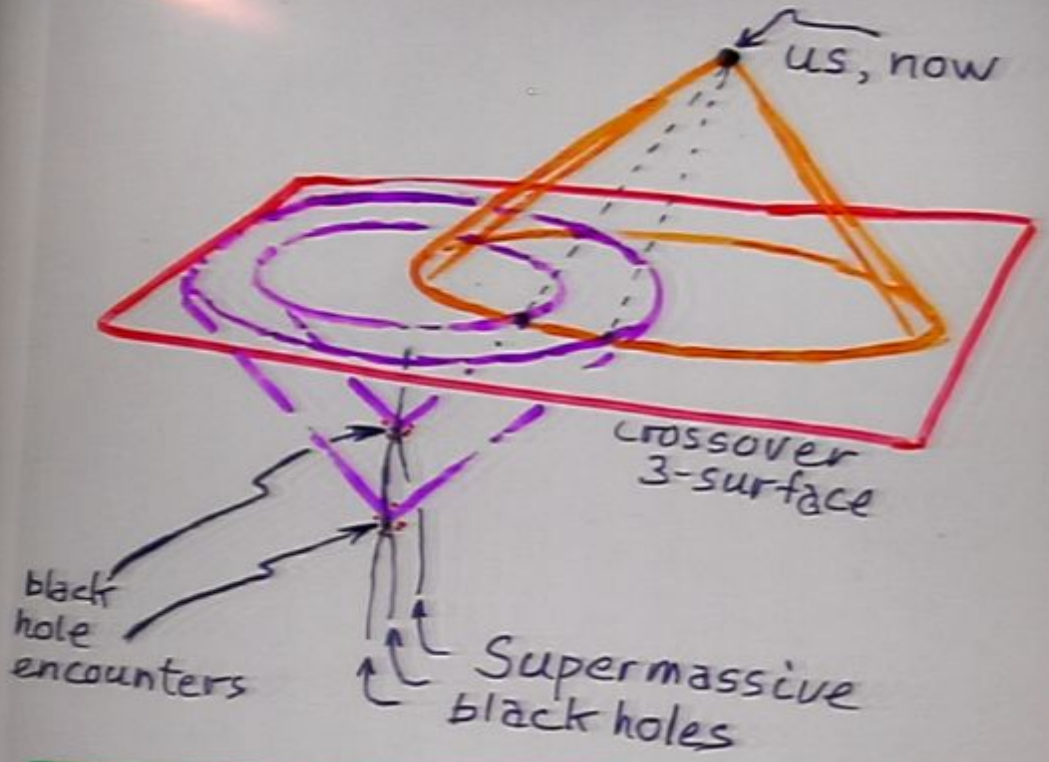

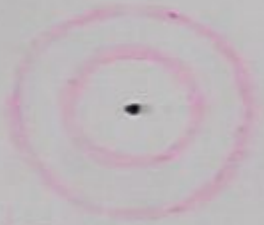

- Anomalous temperature
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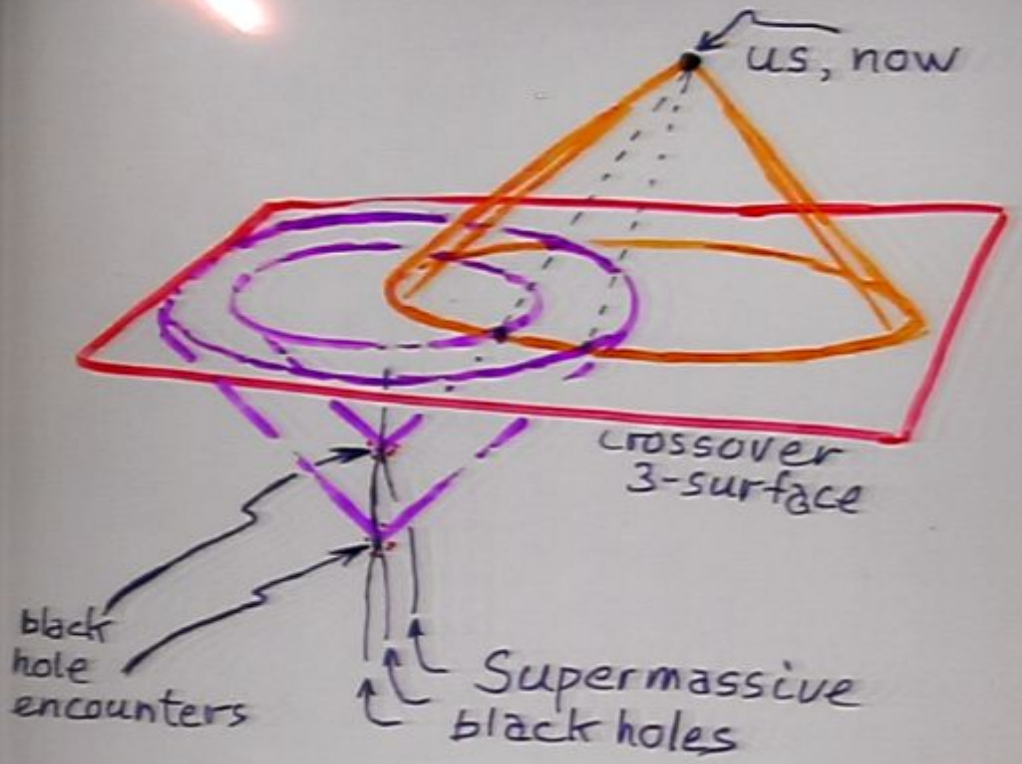
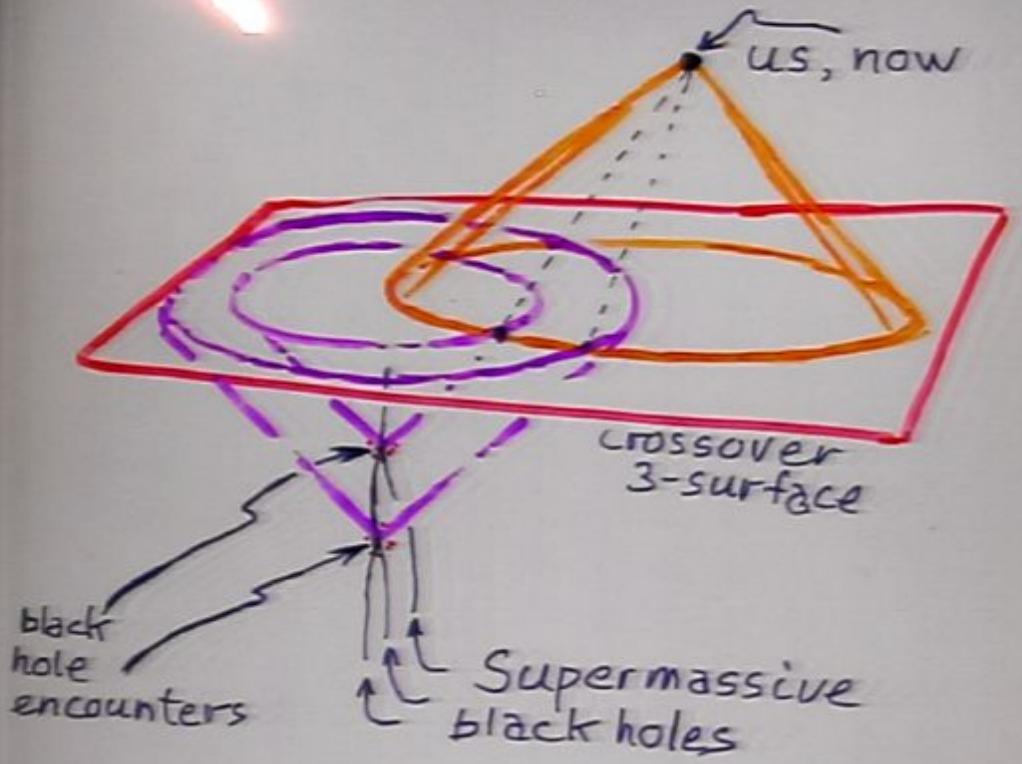
V. Gurzadyan



Anomalous
• temperature

• low va

V. Gurzadyan

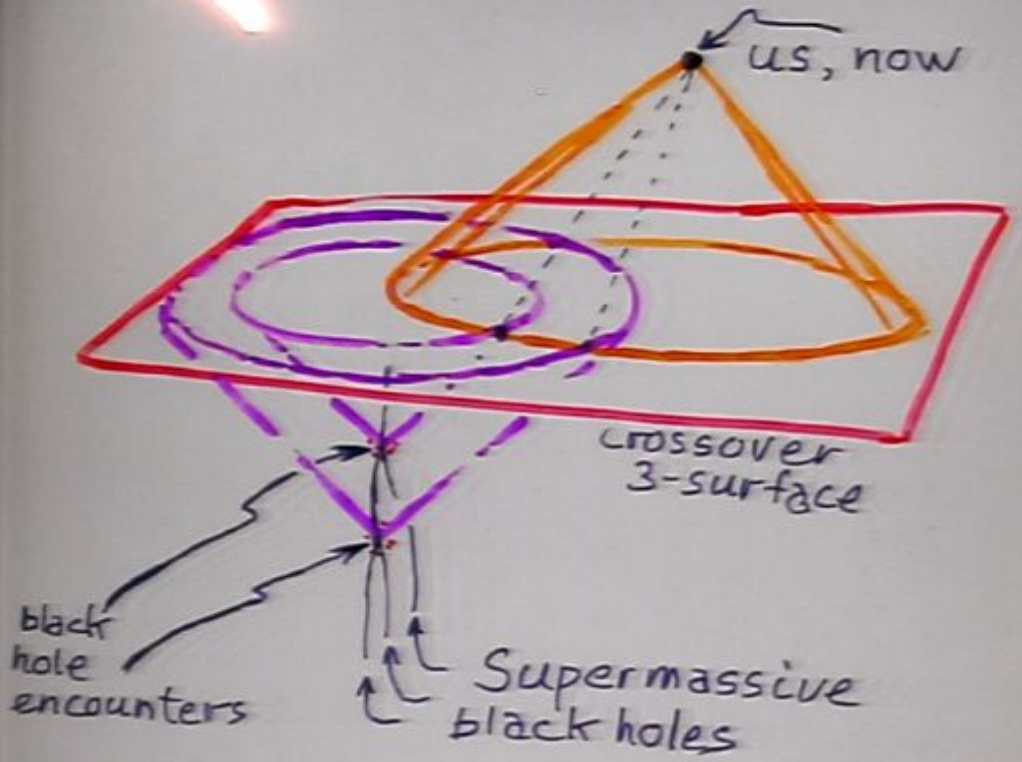




Anomalous
• temperature

• low variance
concentric rings

V. Gurzadyan



Anomalous
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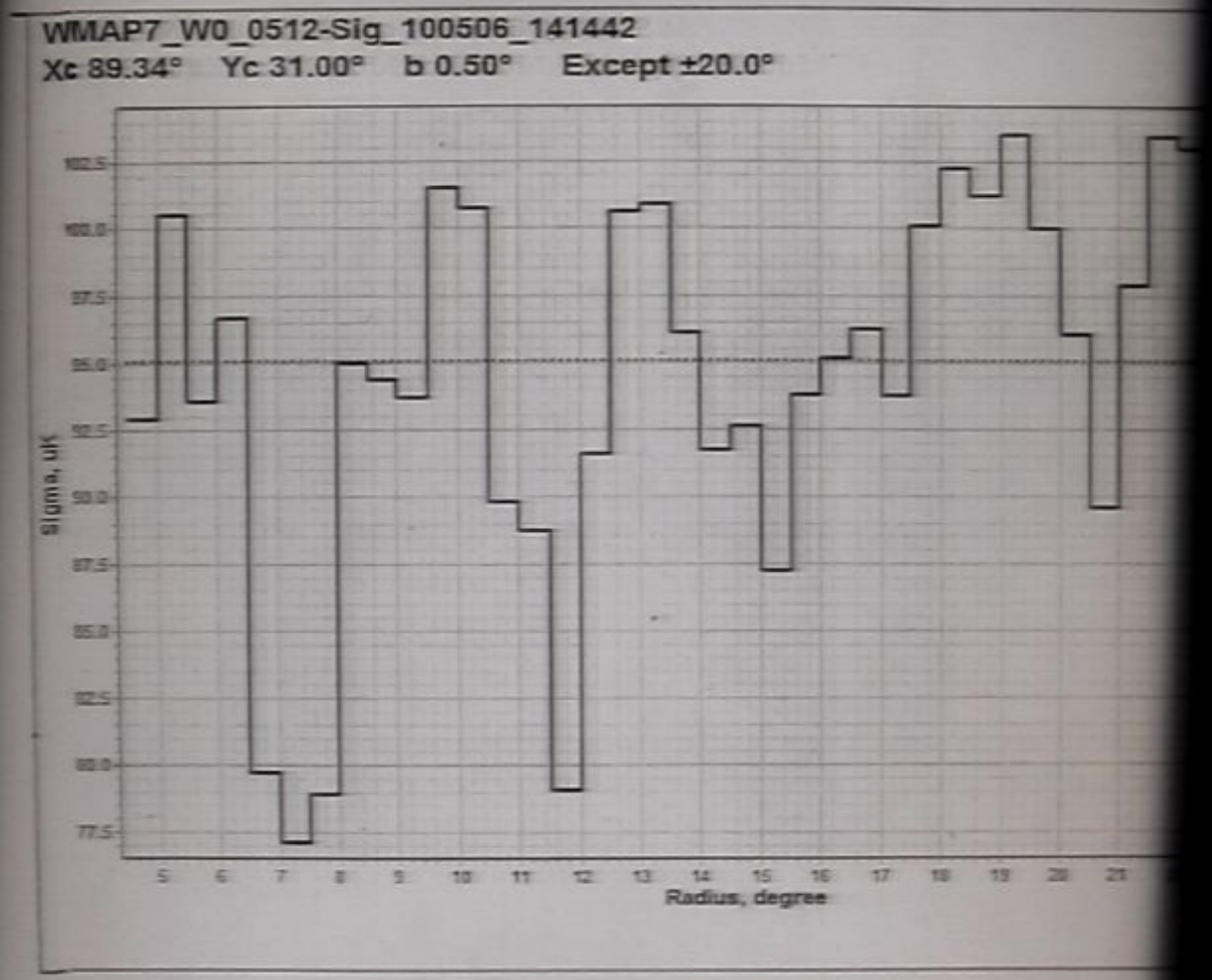
V. Gurzadyan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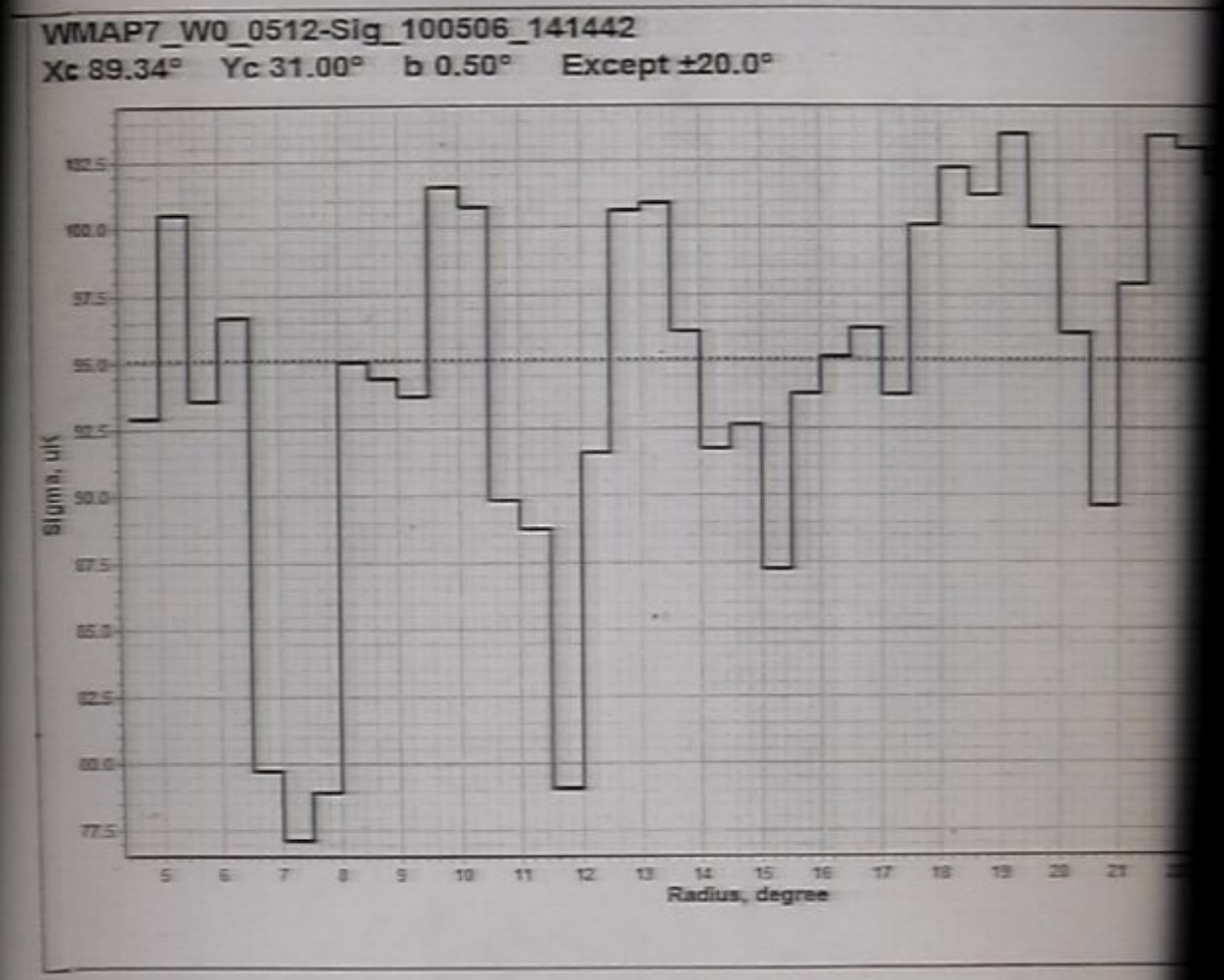
Xc 89.34° Yc 31.00° b 0.50° Except ±20.0°
Sigma, uK
Radius, degree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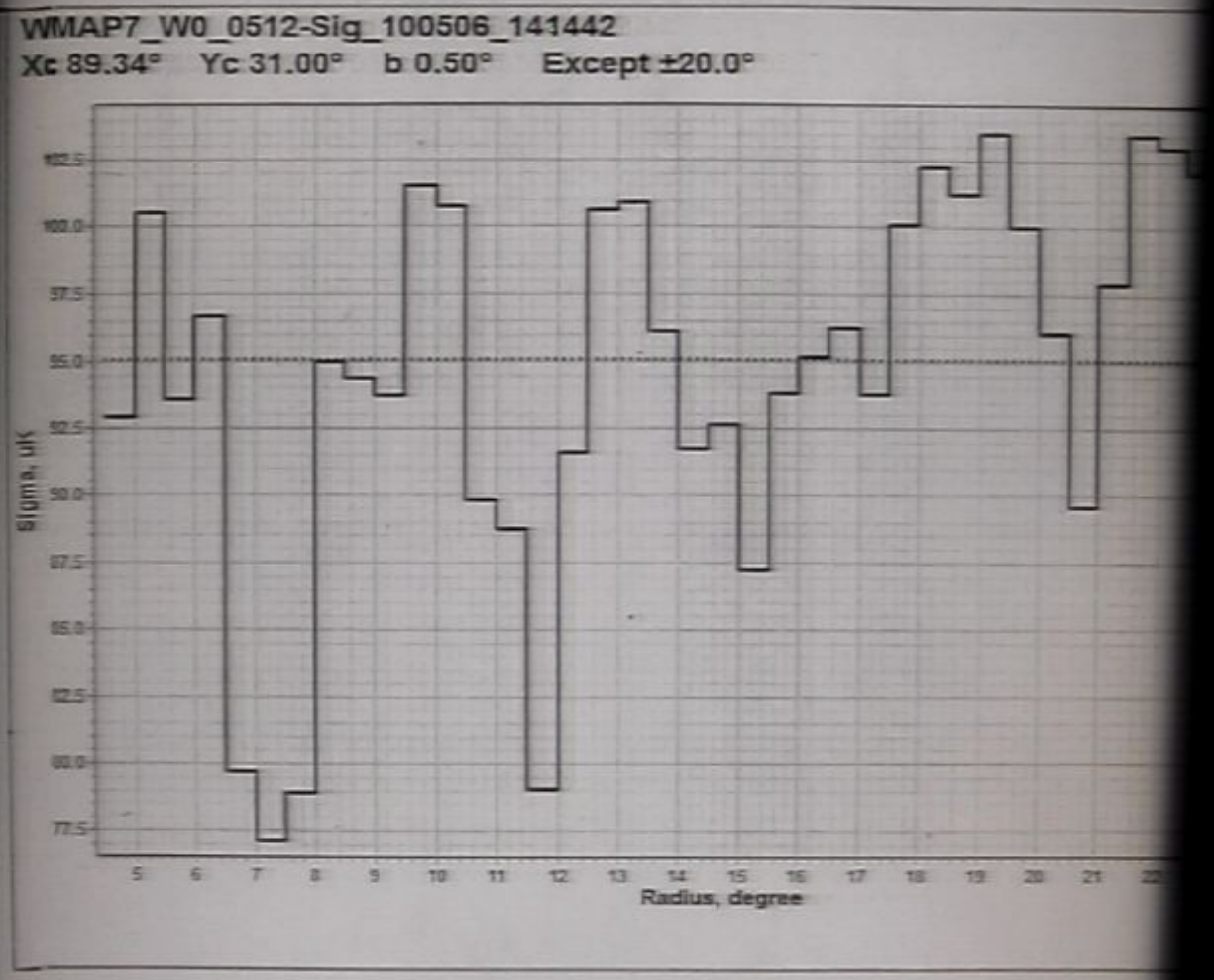
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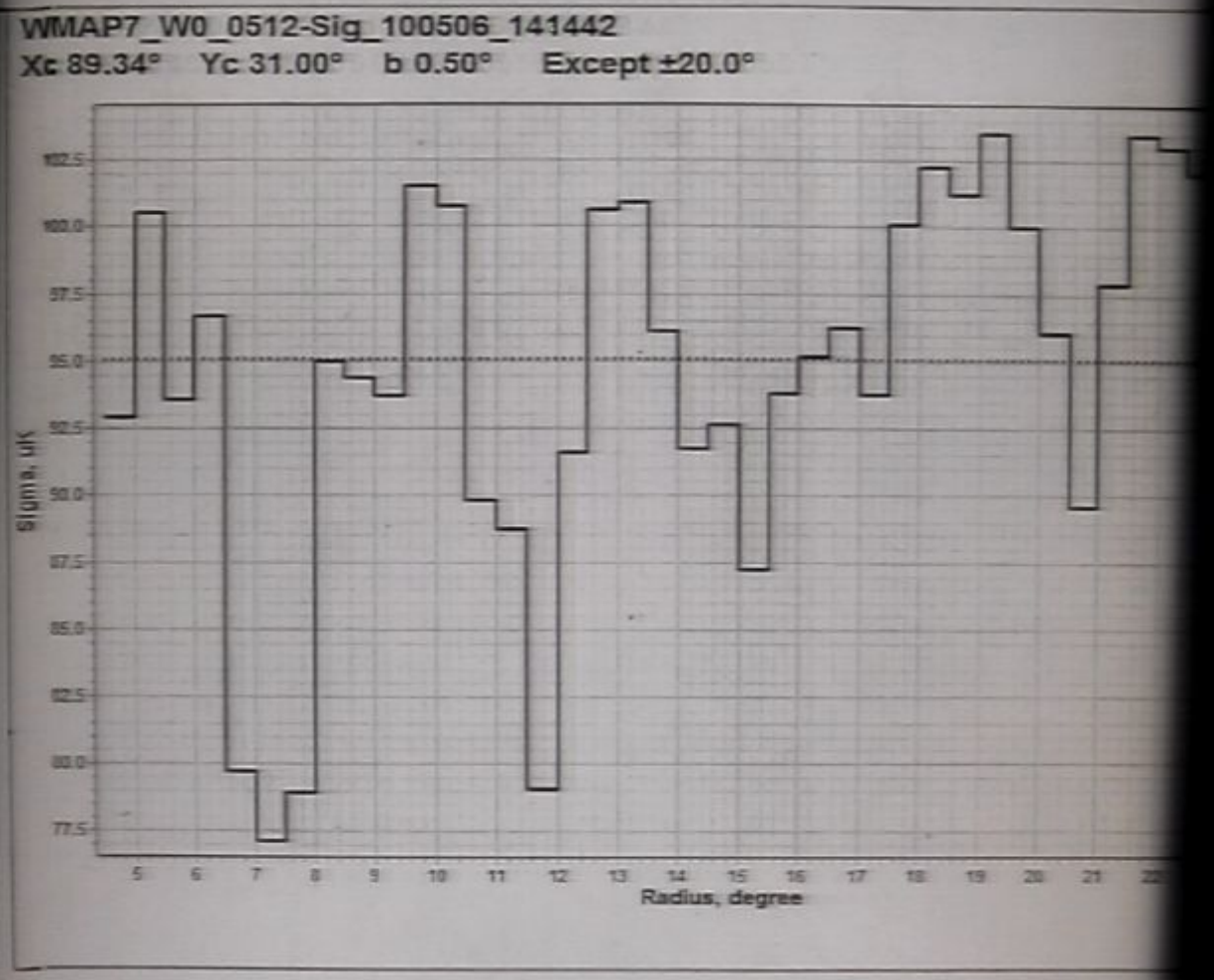
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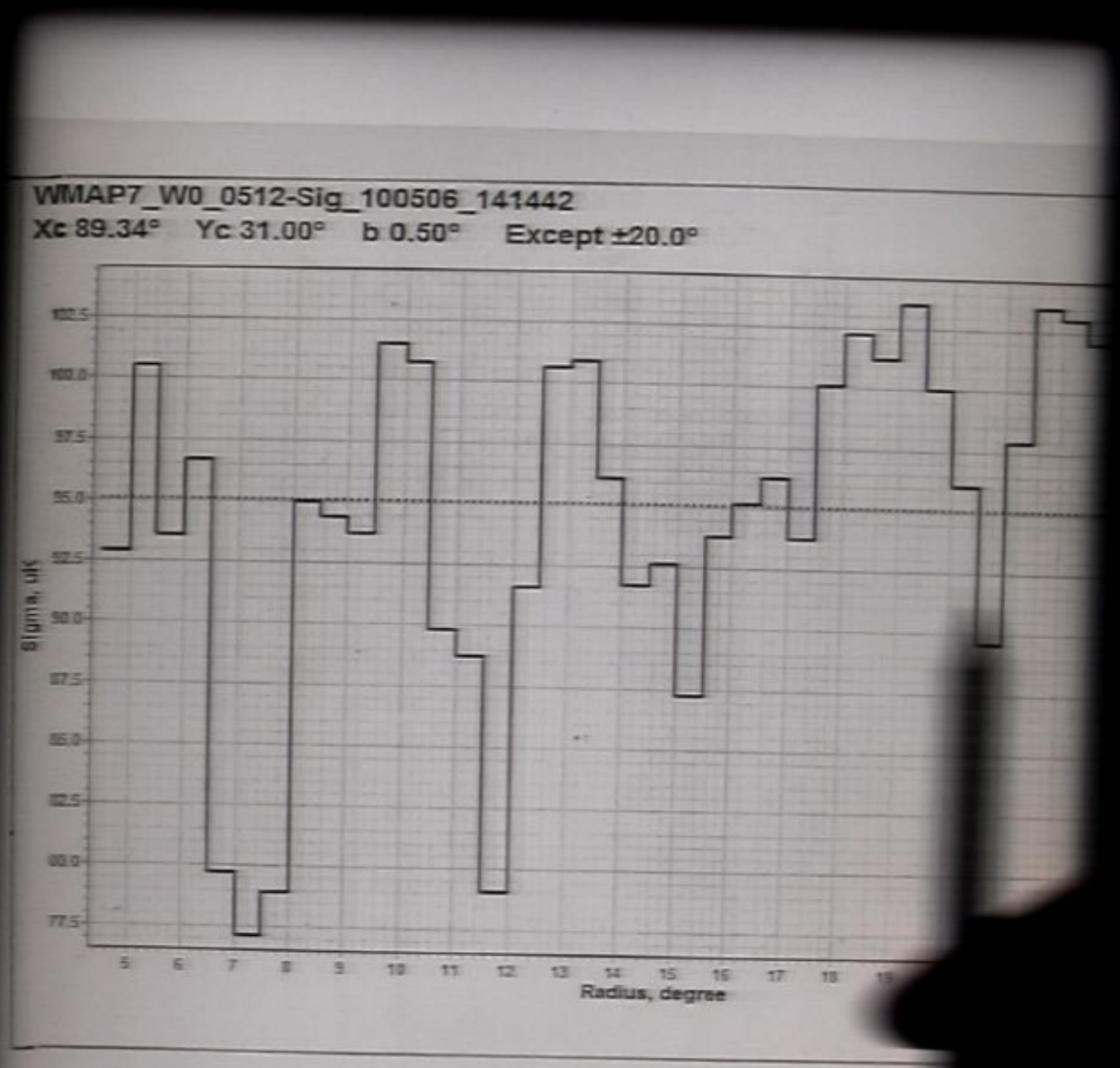
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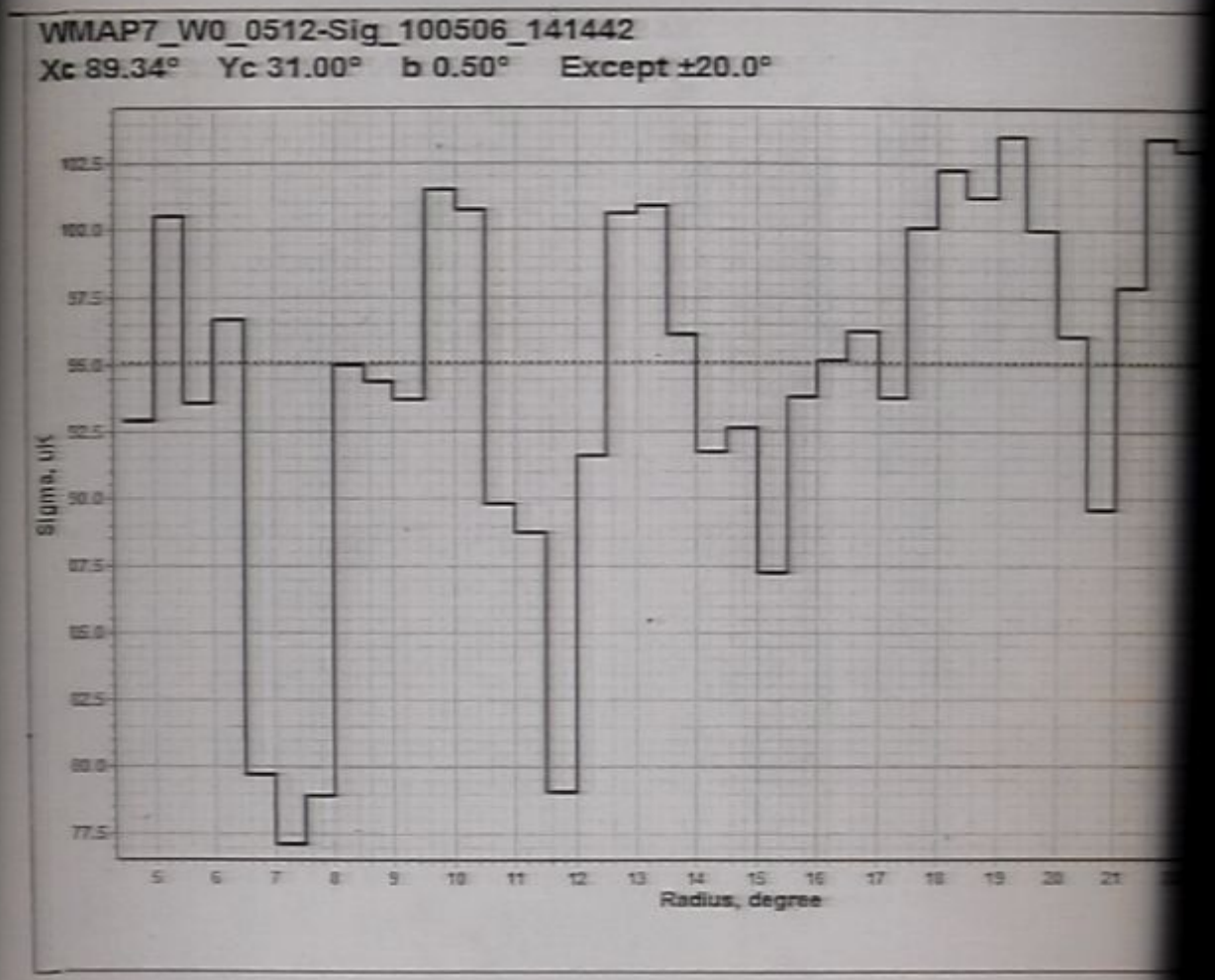
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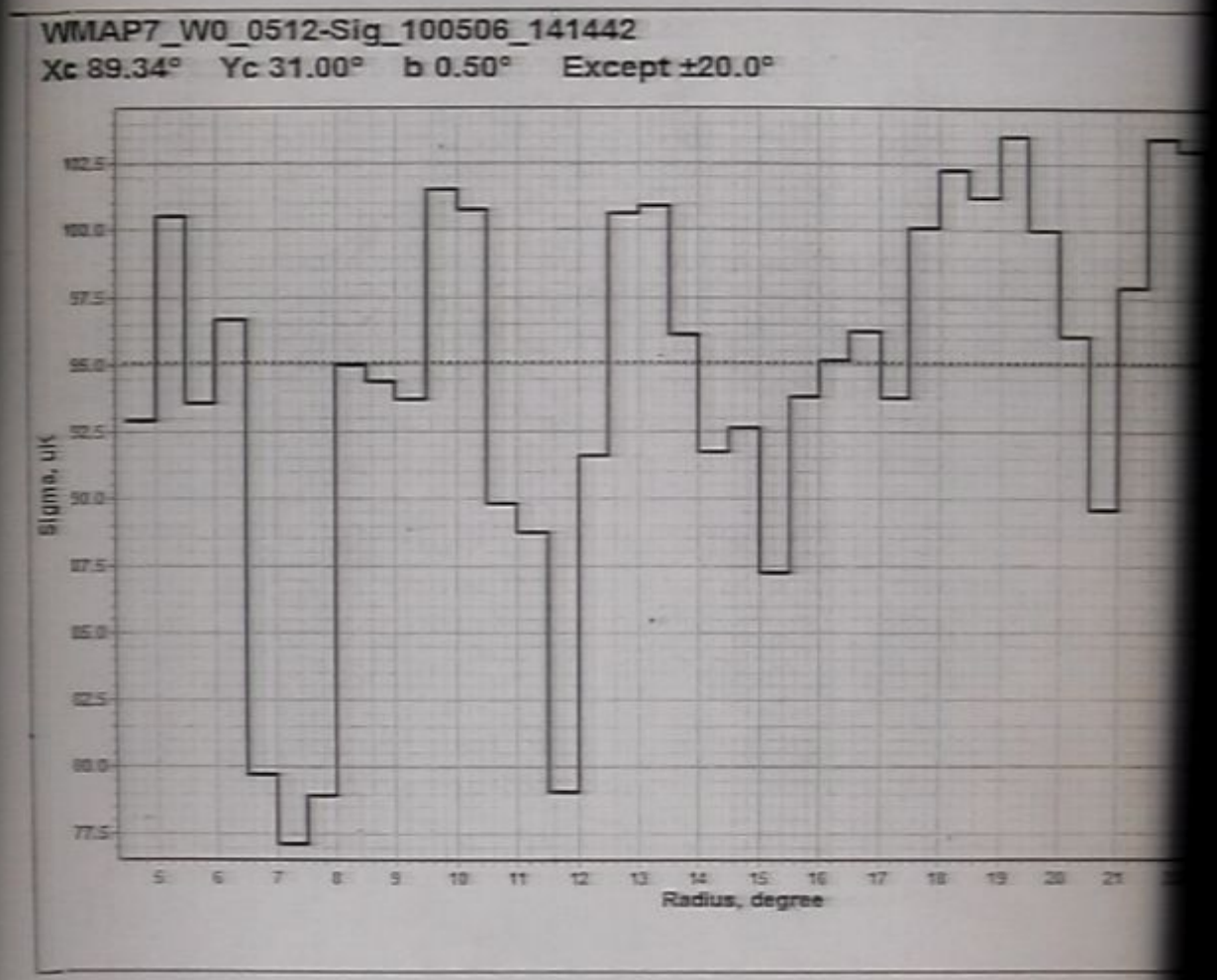
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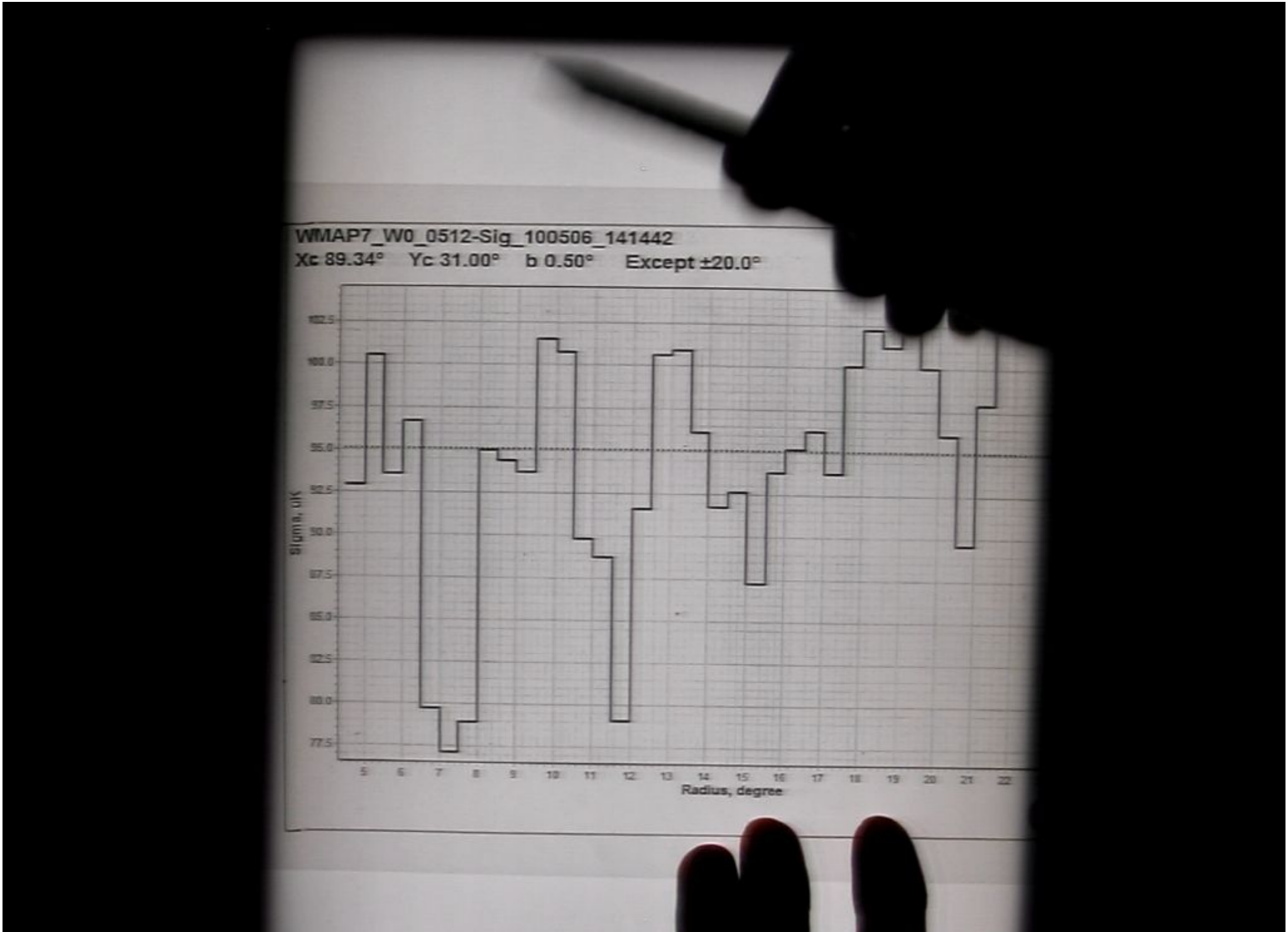
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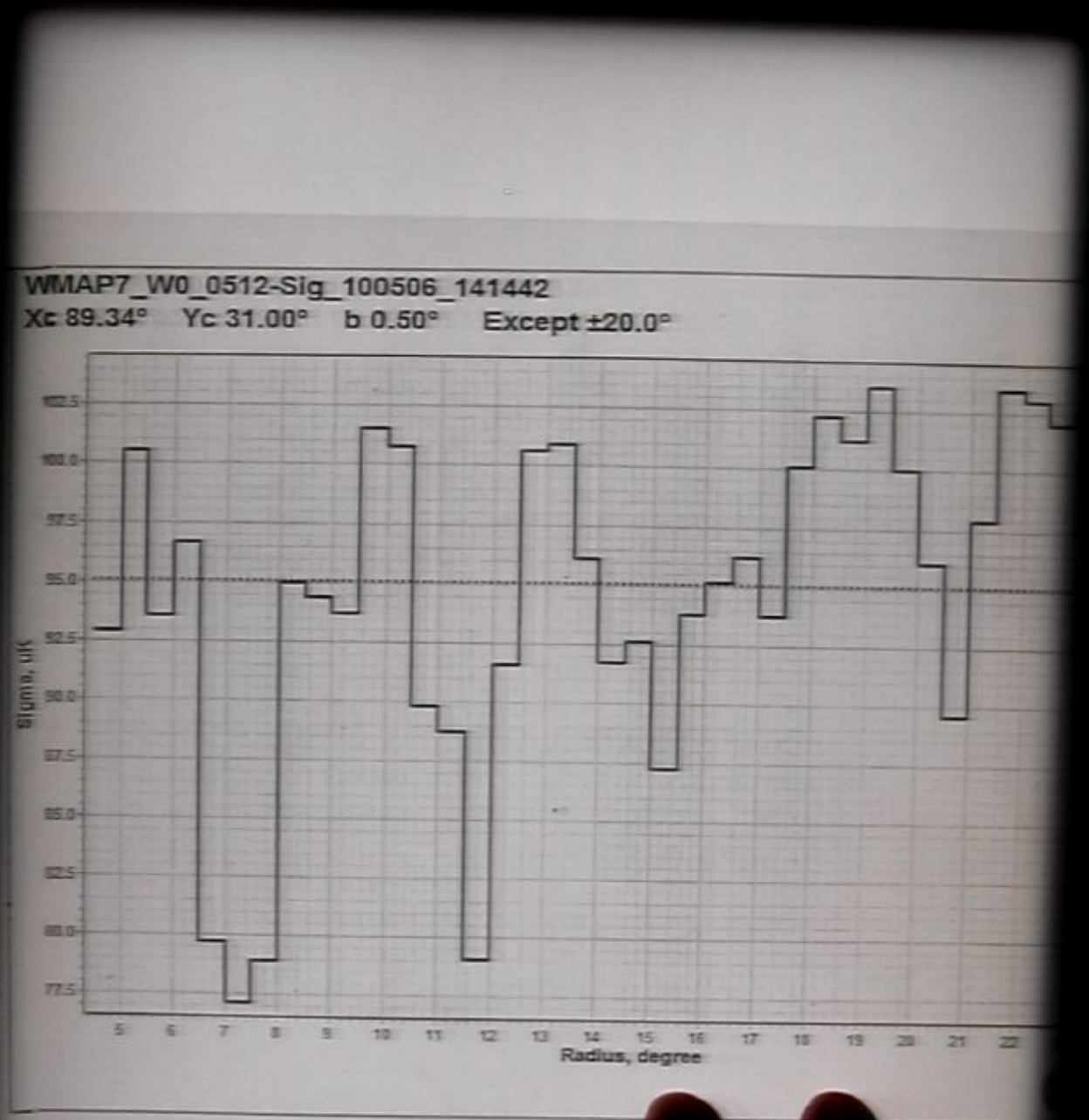
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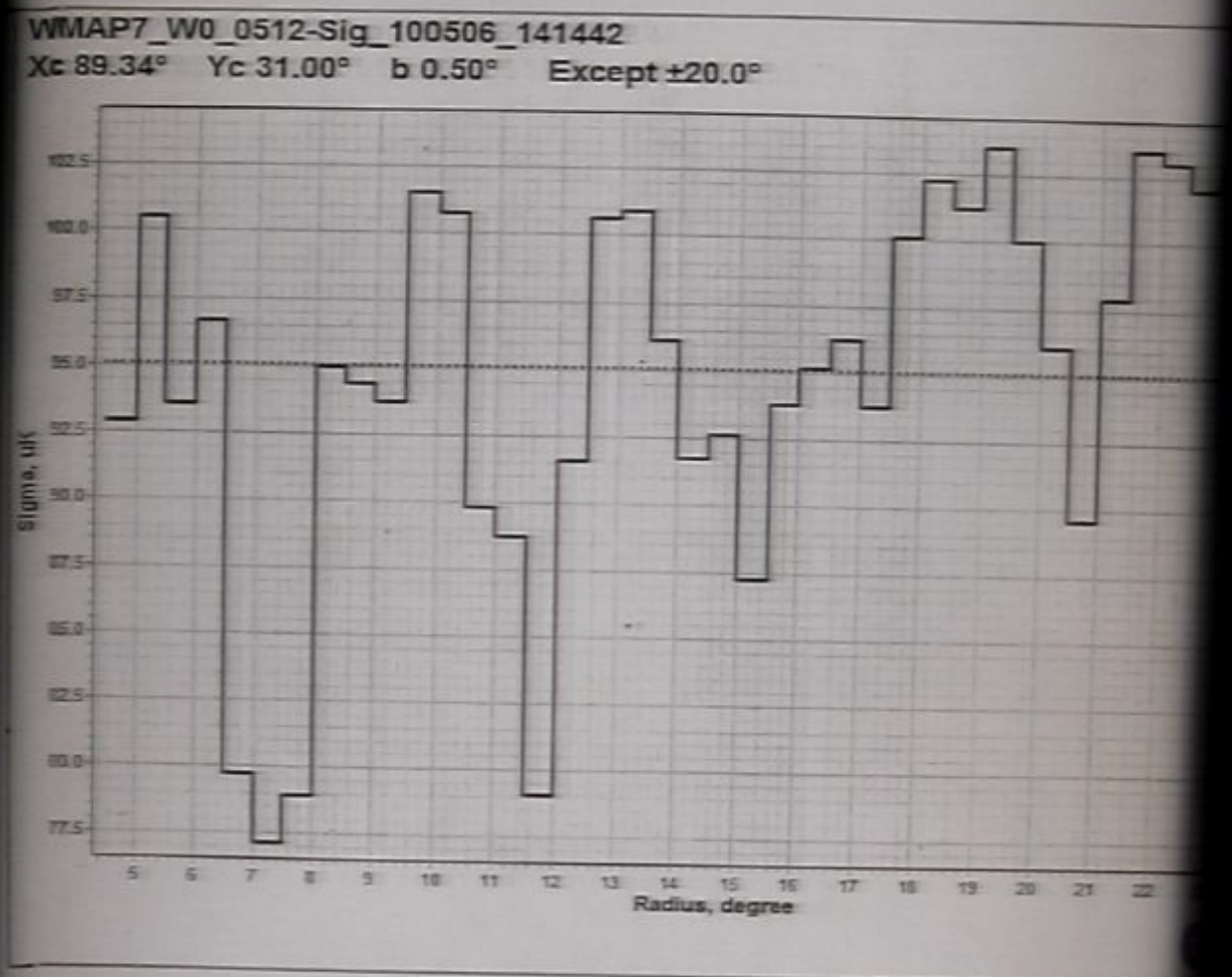
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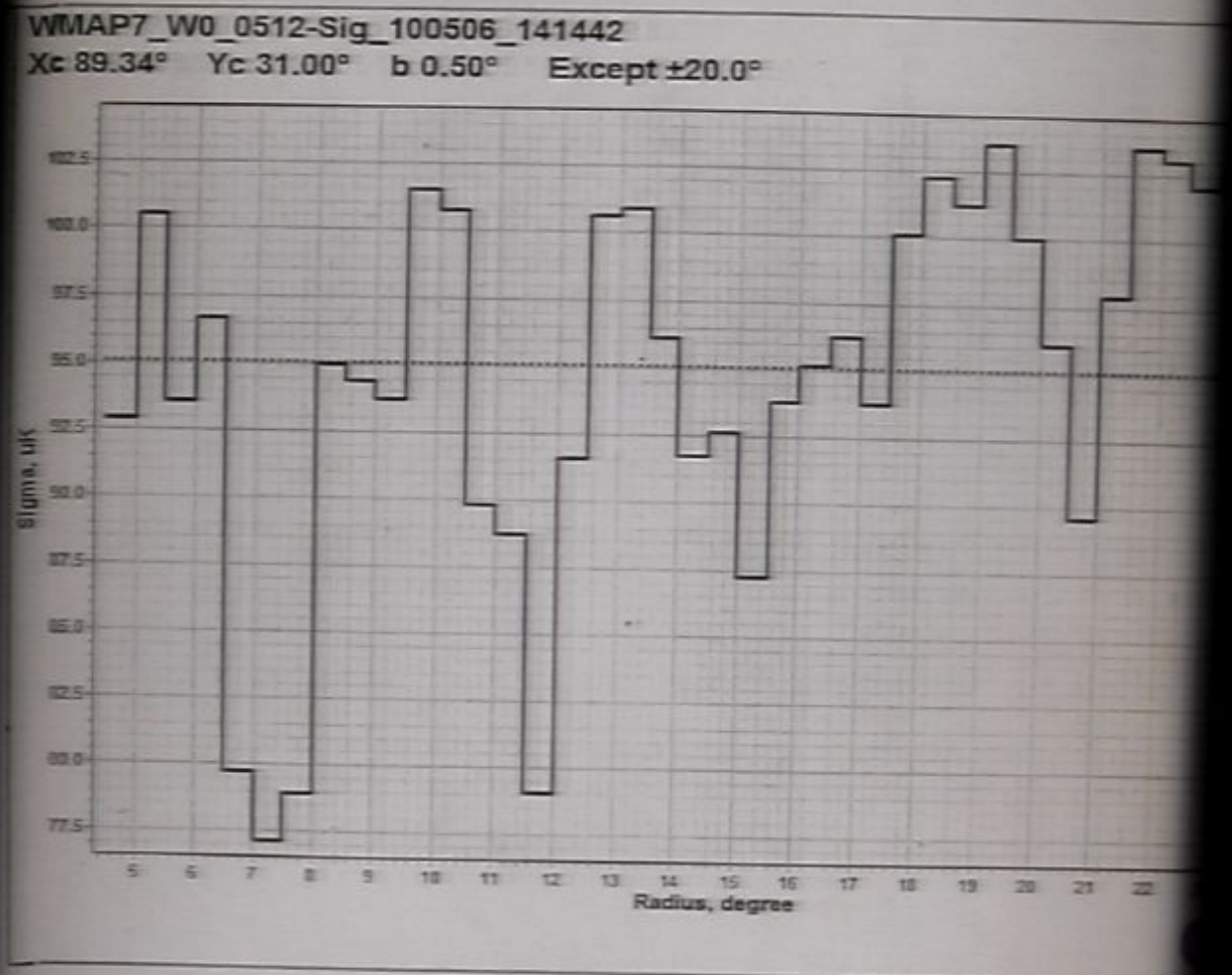
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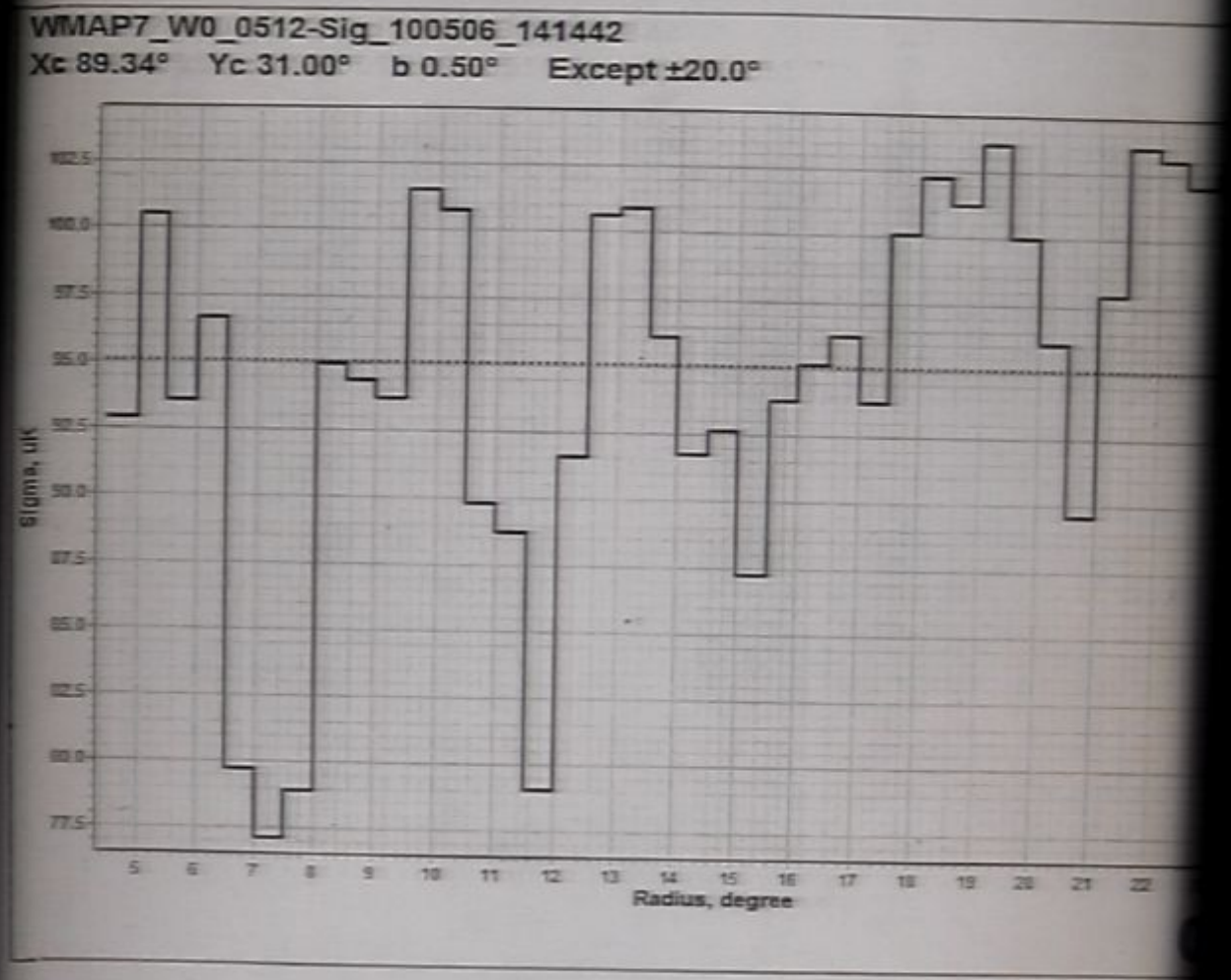
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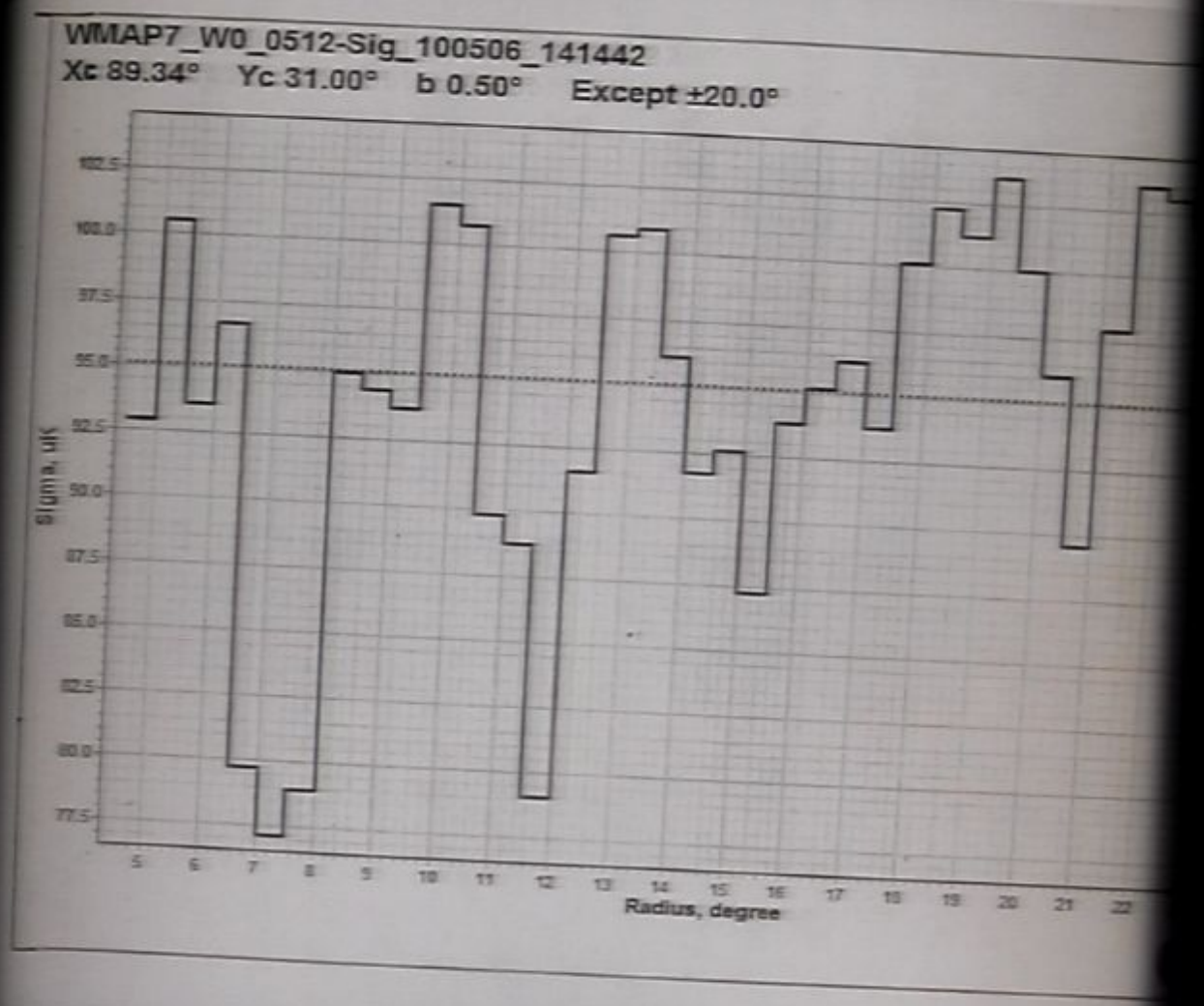
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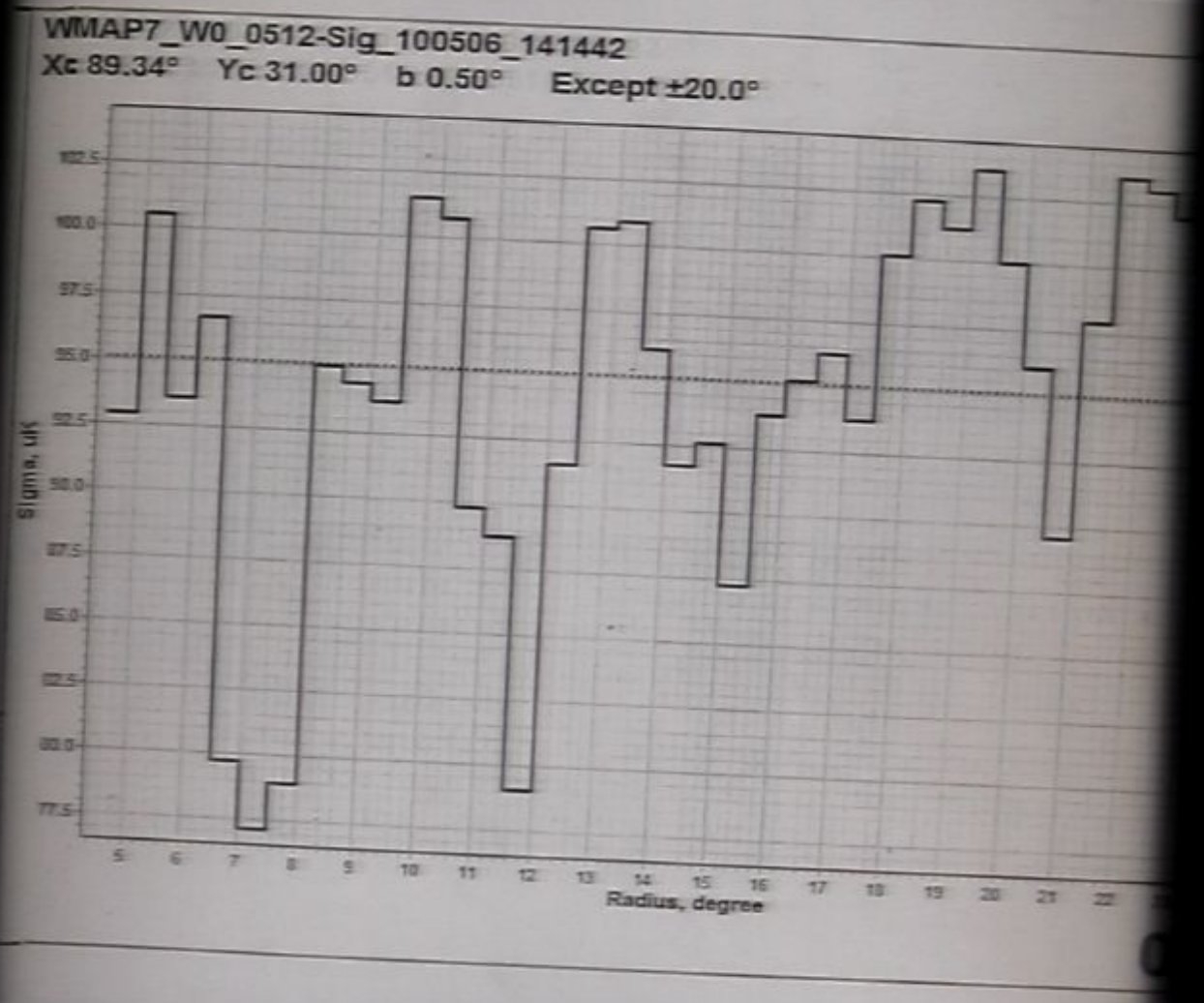
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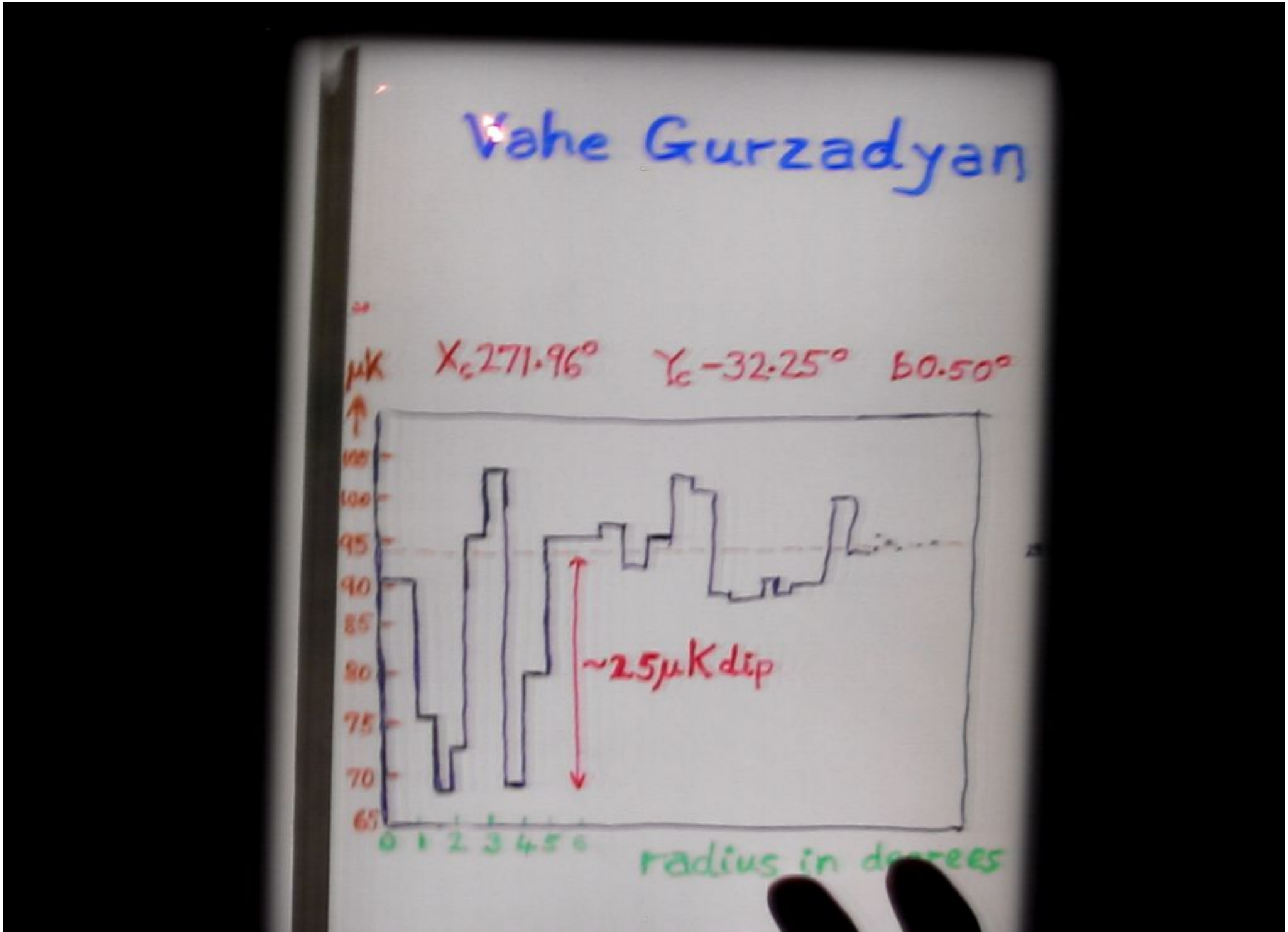
Vahe Gurzadyan
μK
X_c 271.96°
Y_c −32.25°
60.50°
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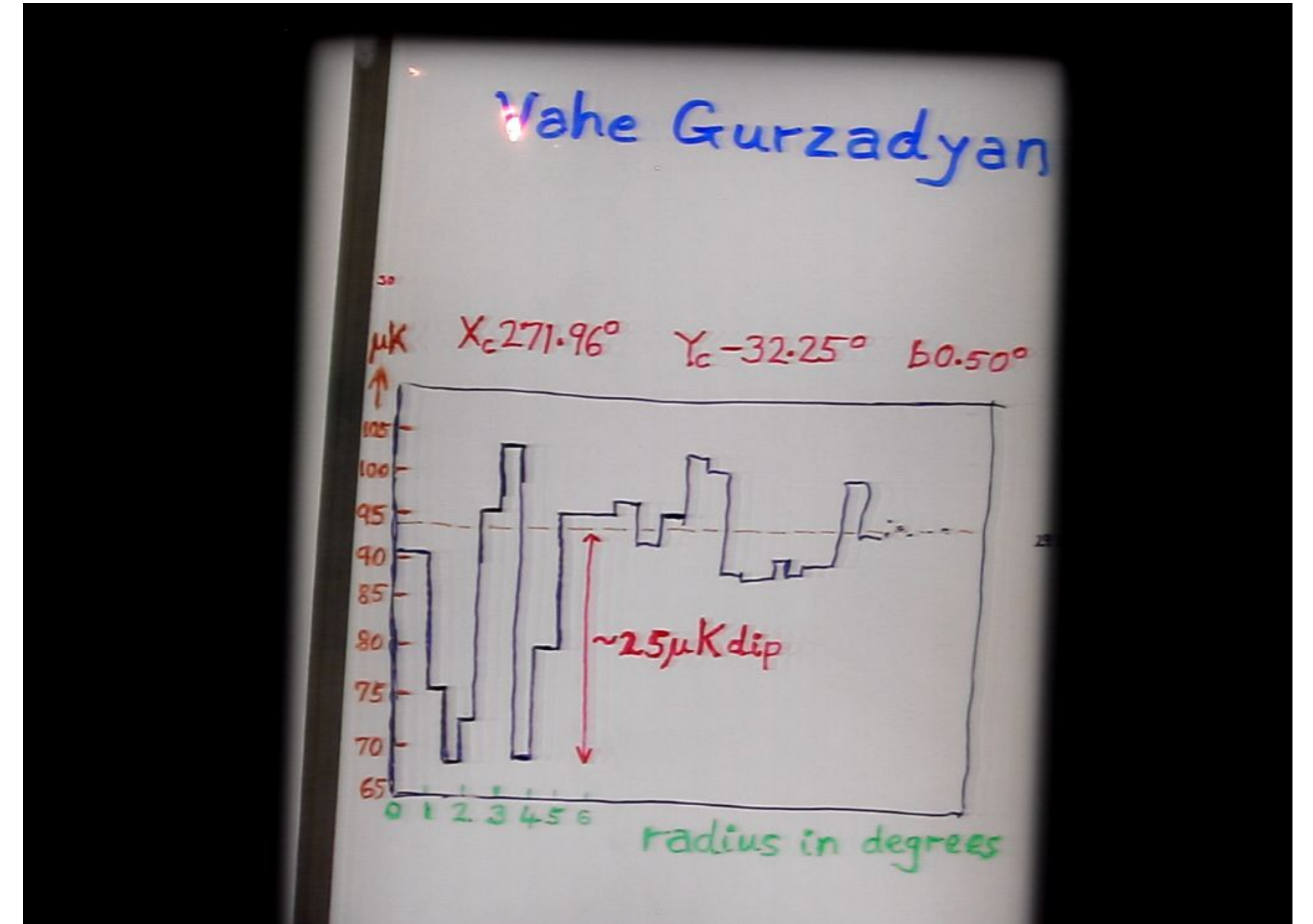
~25μK dip
0 1 2 3 4 5 6
radius in degrees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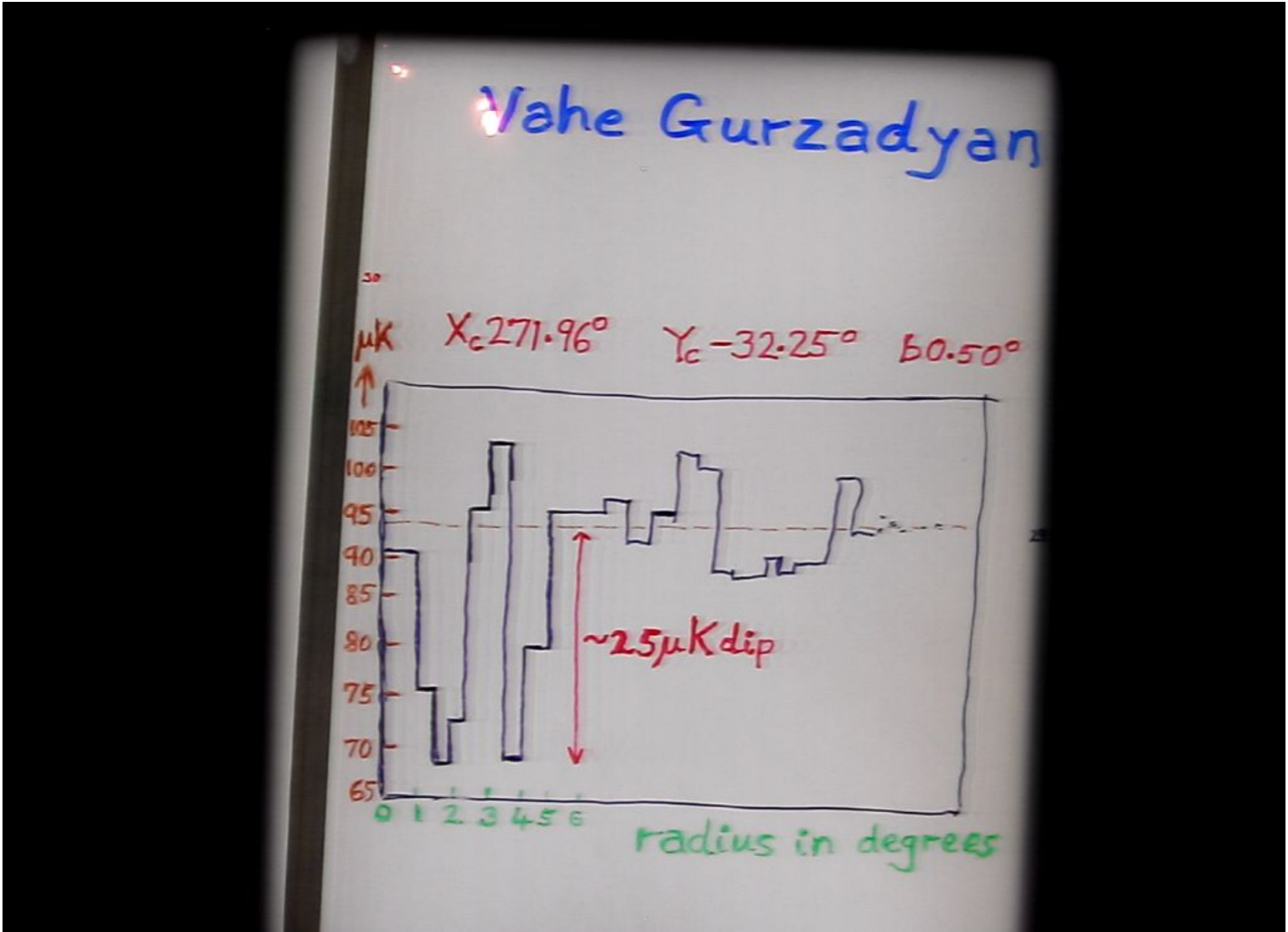
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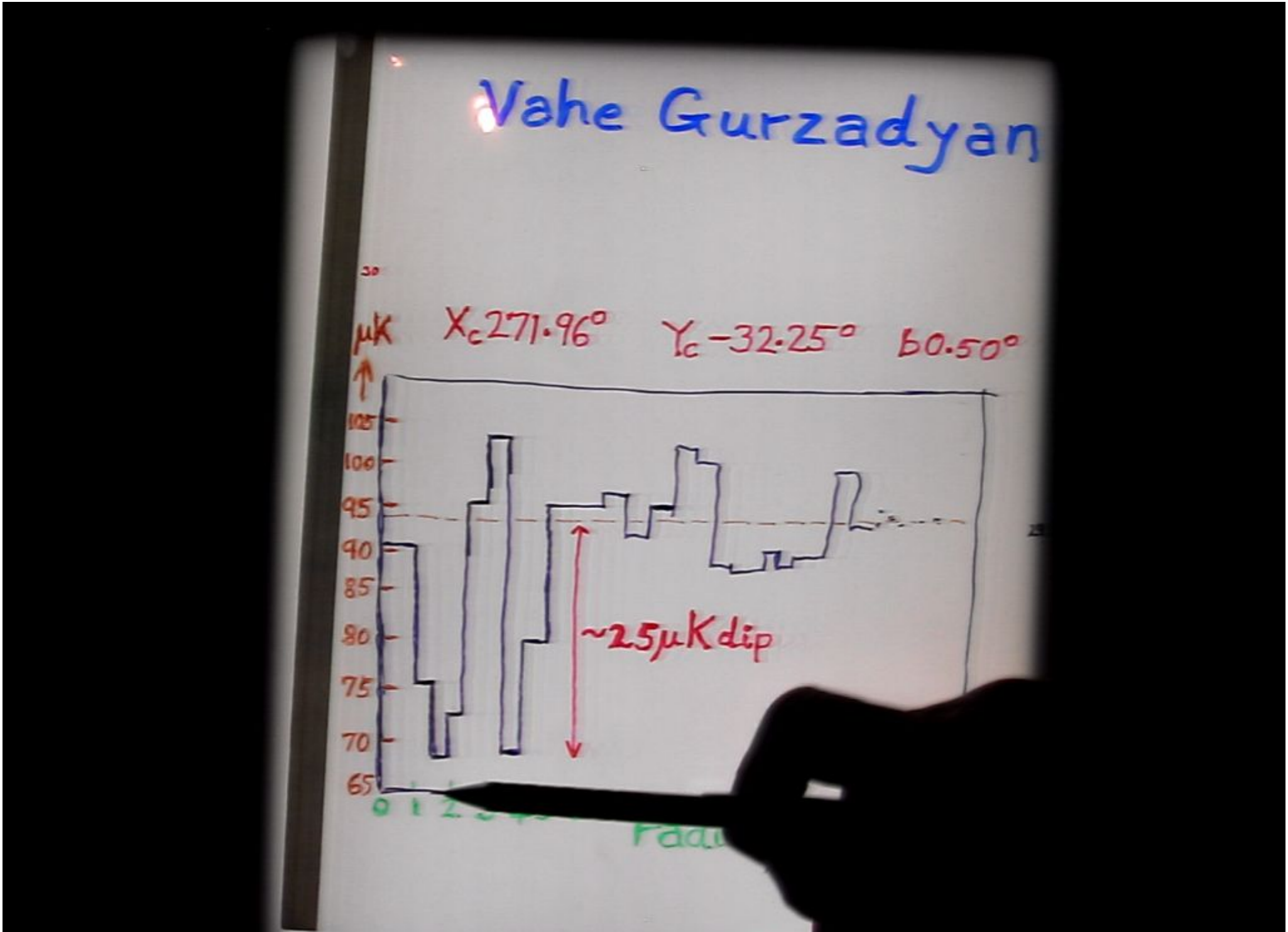
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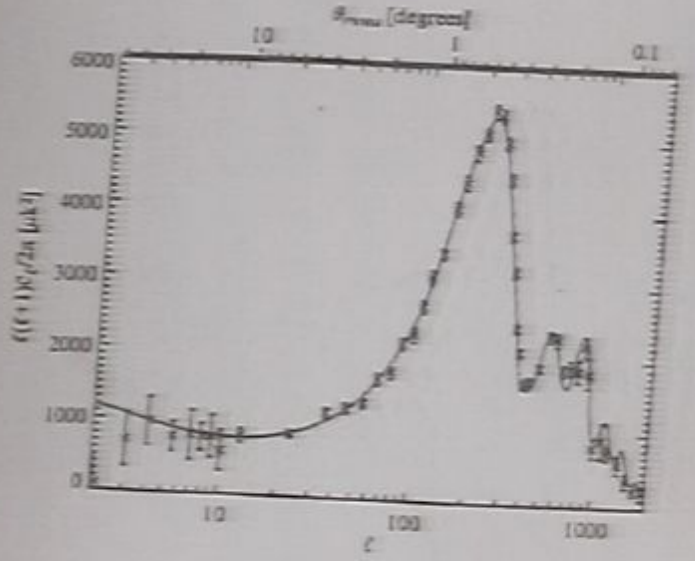
θ_{FWHM} [degrees]
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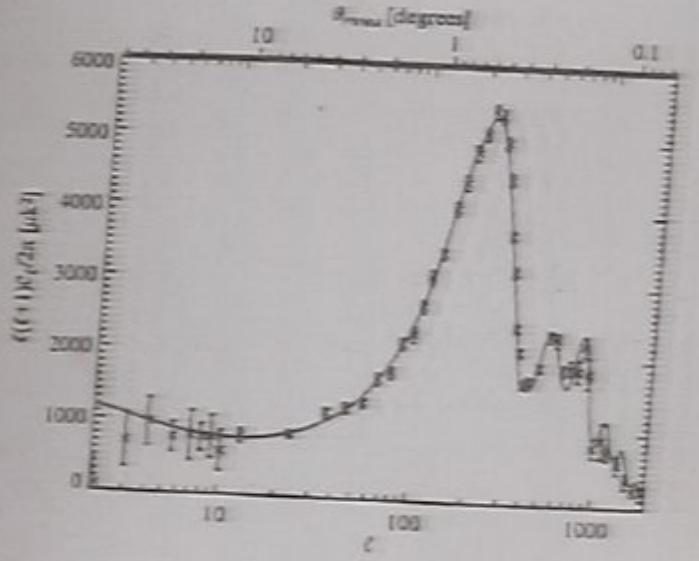
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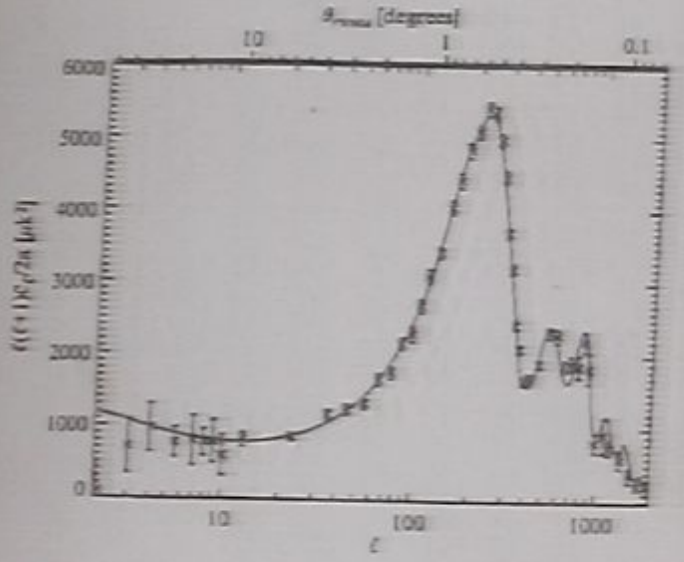
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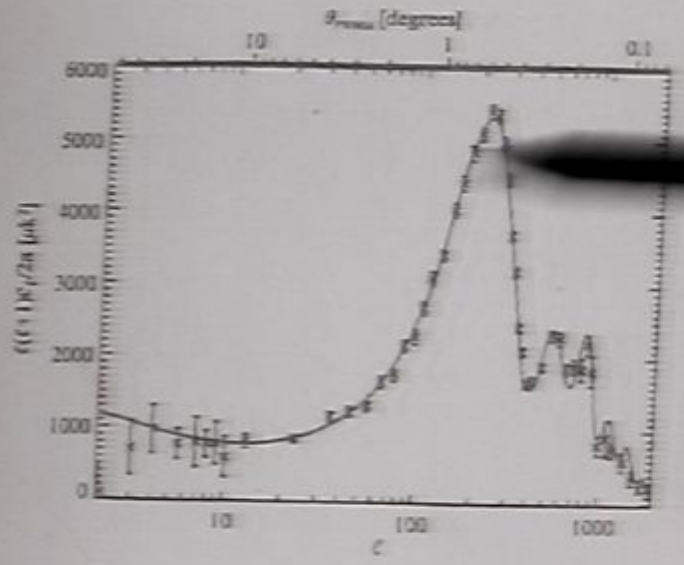
θ_{FWHM} [degrees]
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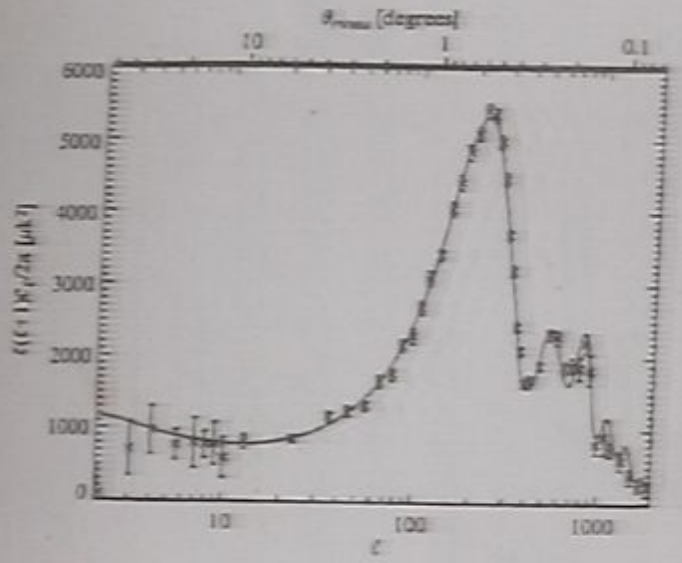
$\vartheta_{c.m.}$ [degrees]
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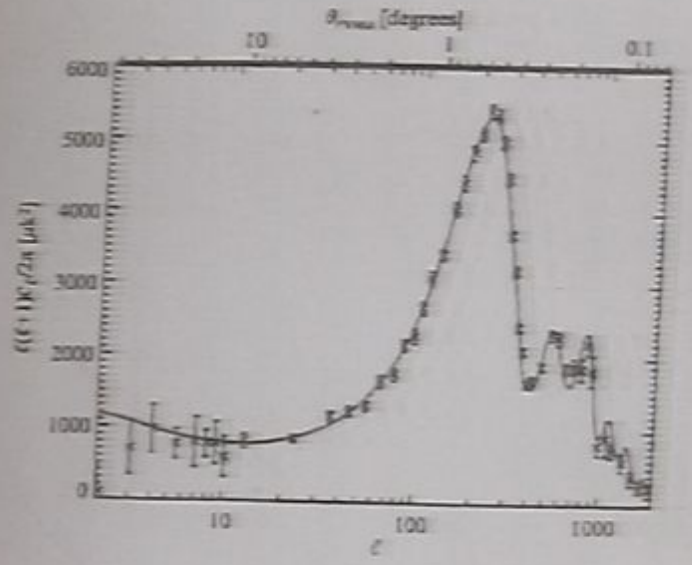
θ_{FWHM} [degrees]
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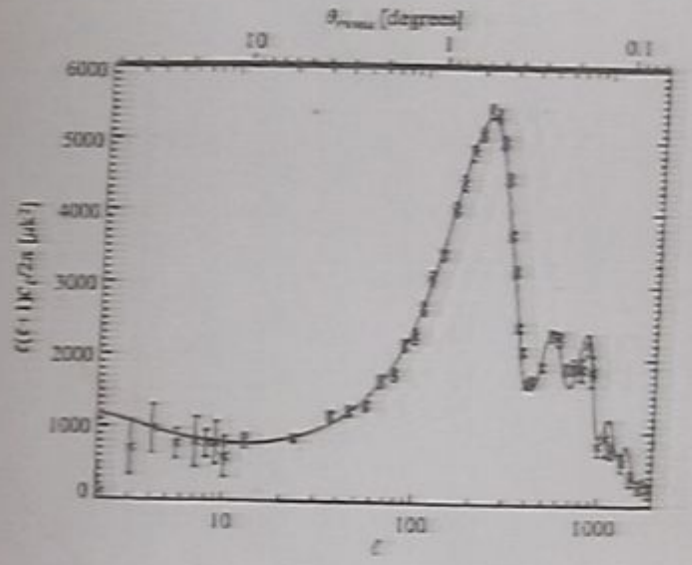
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1000
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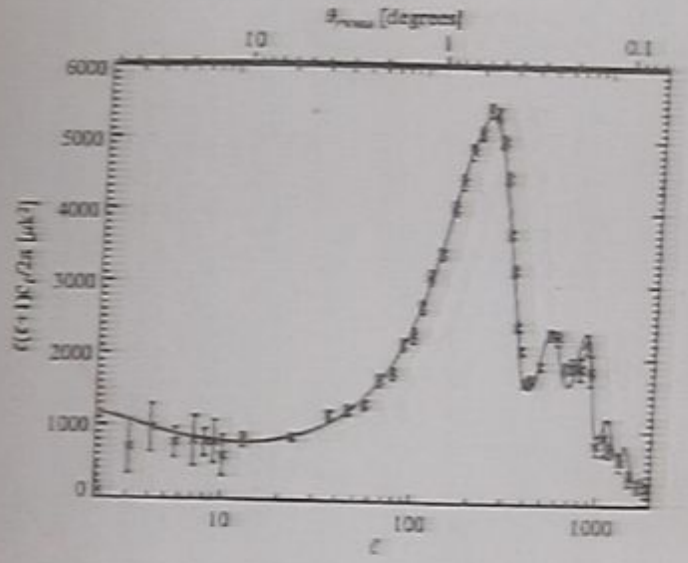
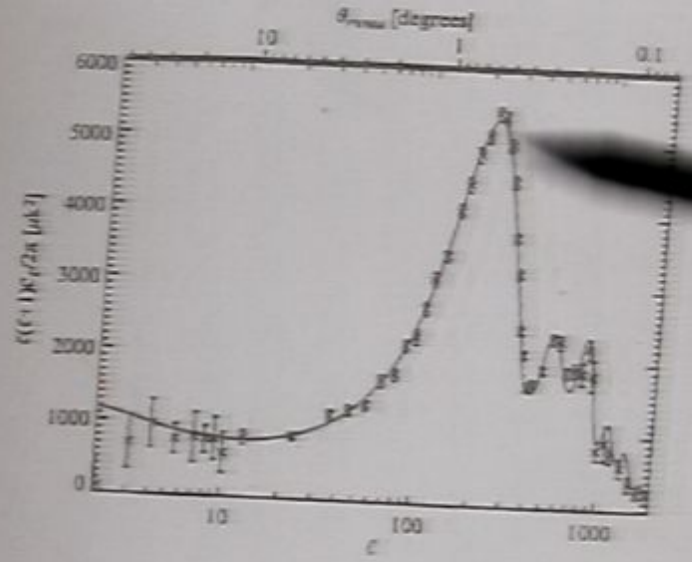

θ_{FWHM} [degrees]
10
1
0.1
6000
5000
4000
3000
2000
1000
0
$\ell(\ell+1)C_\ell/2\pi$ [μK^2]
10
100
1000
ℓ


θ_{WMAP} [degrees]
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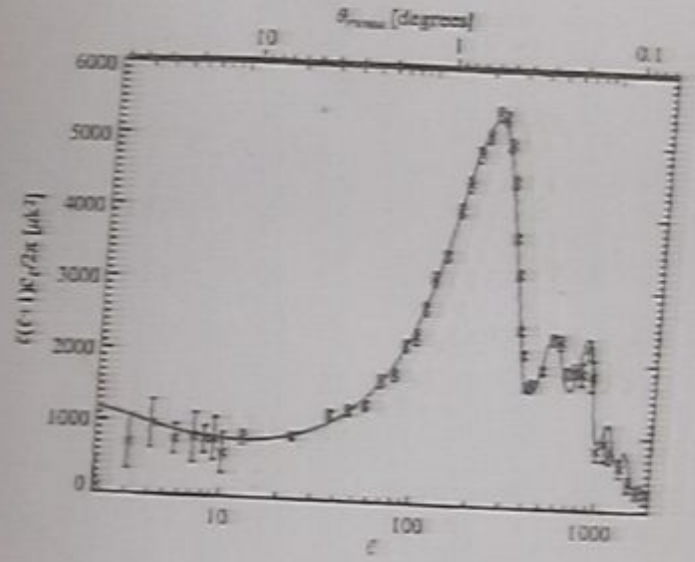
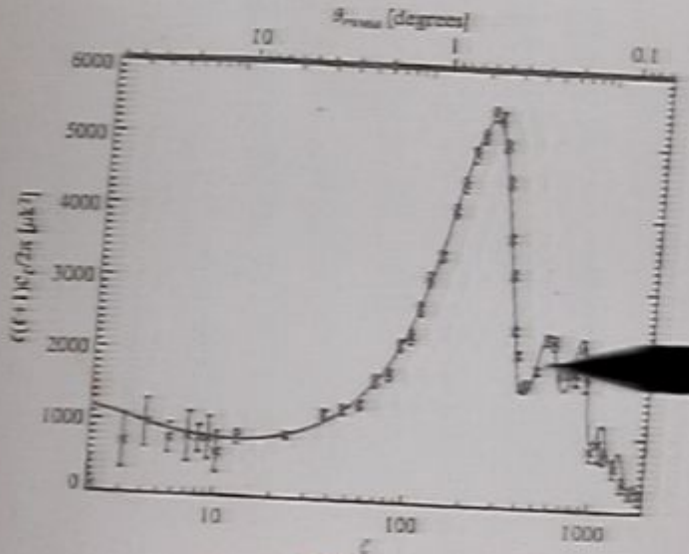
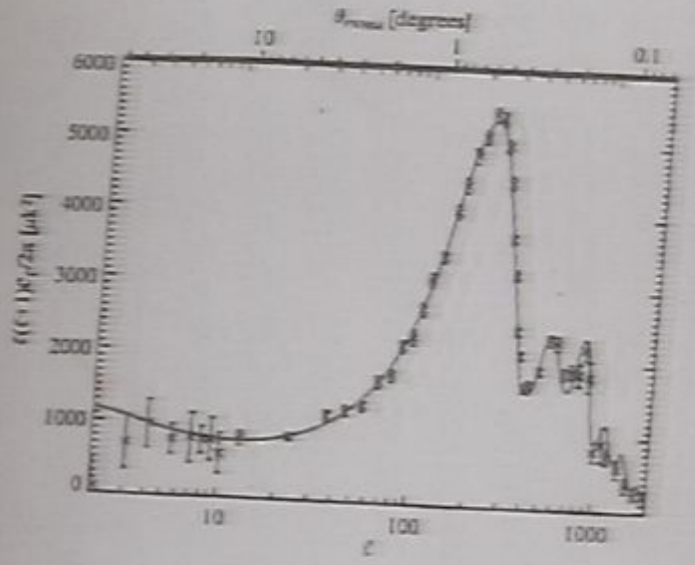
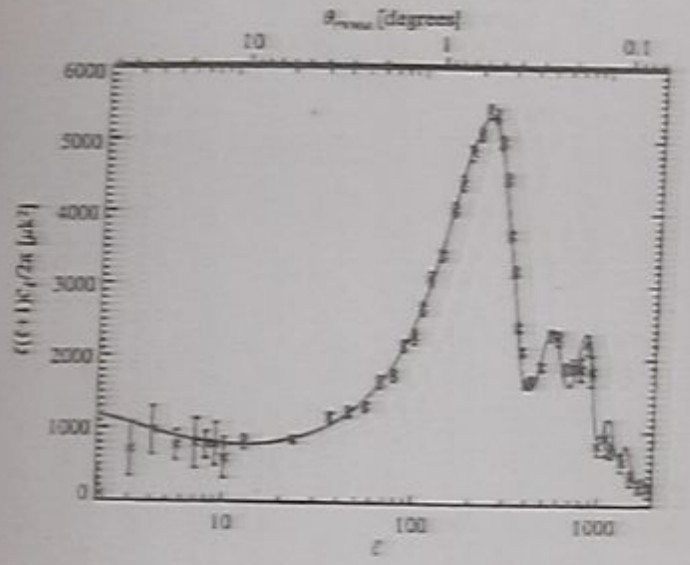
1
0.1
6000
5000
4000
3000
2000
1000
0
10
100
1000
ℓ


θ_{FWHM} [degrees]
10
1
0.1
6000
5000
4000
3000
2000
1000
0
10
100
1000
ℓ


θ_{FWHM} [degrees]
10
1
0.1
6000
5000
4000
3000
2000
1000
0
$\ell(\ell+1)C_\ell/2\pi$ [μK^2]
10
100
1000
ℓ


θ_{FWHM} [degrees]
10
1
0.1
6000
5000
4000
3000
2000
1000
0
10
100
1000
ℓ


θ_{FWHM} [degrees]
10
1
0.1
6000
5000
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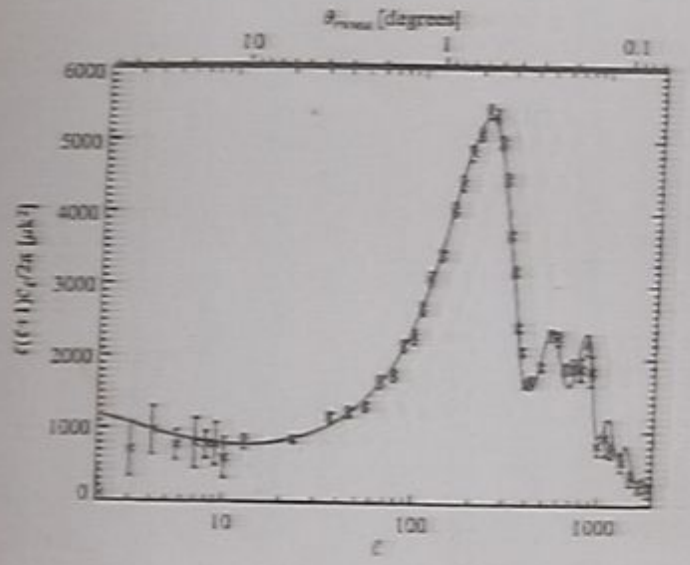
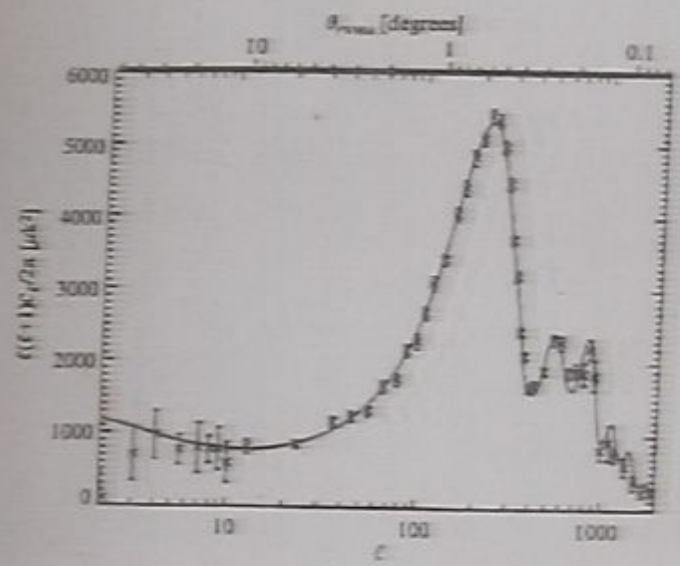
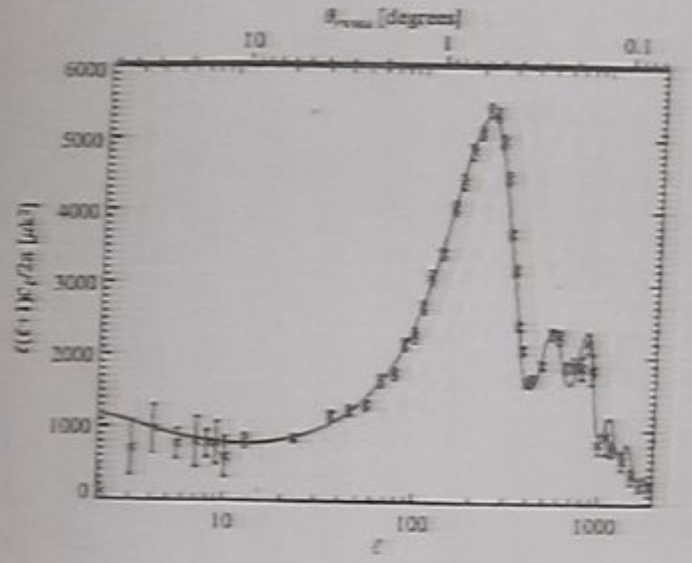
3000
2000
1000
0
10
100
1000
ℓ

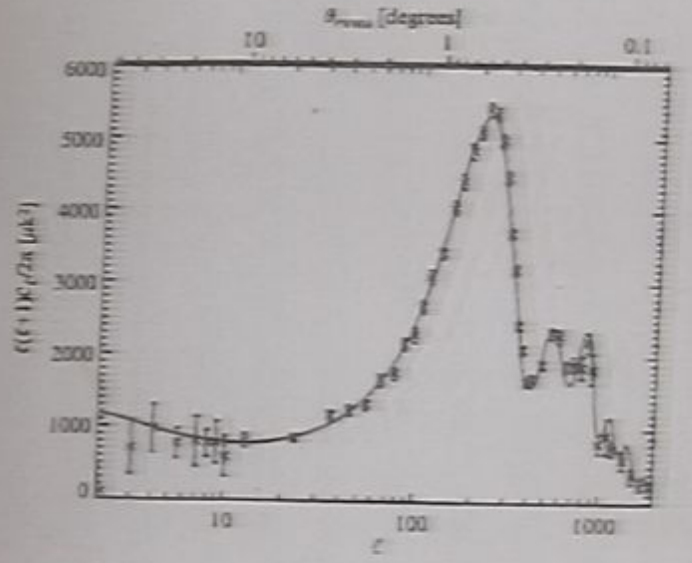

θ_{FWHM} [degrees]
10
1
0.1
6000
5000
4000
3000
2000
1000
0
$\ell(\ell+1)C_\ell/2\pi$ [μK^2]
10
100
1000
ℓ

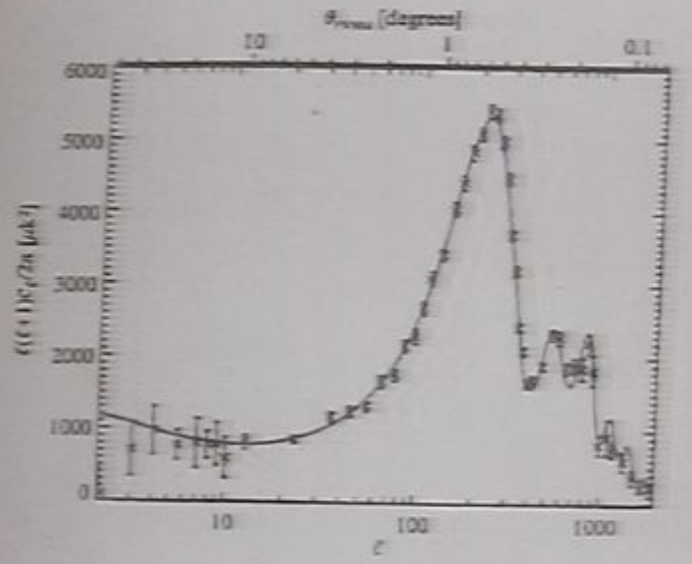


[degrees]
10
1
0.1
6000
5000
4000
3000
2000
1000
0
10
100
1000

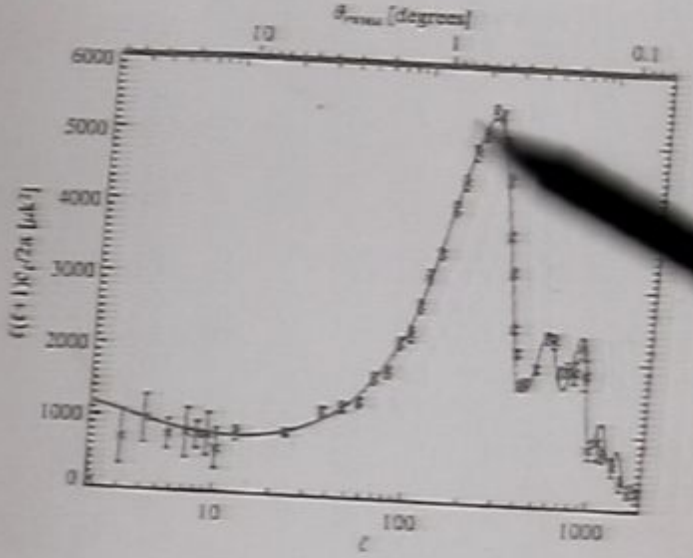


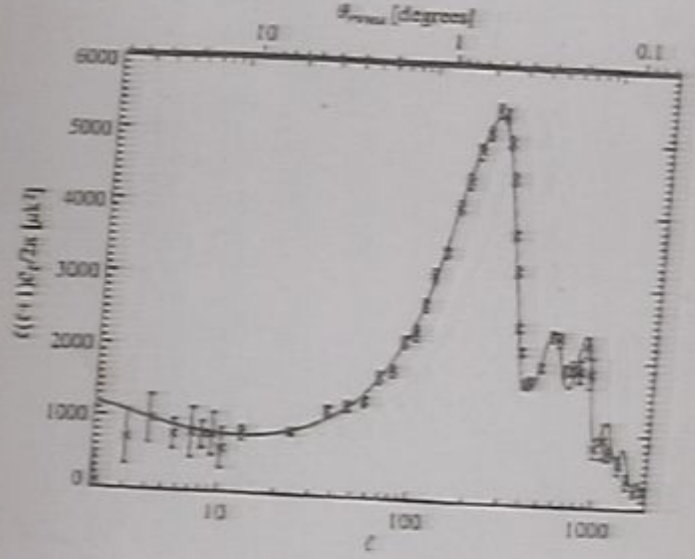
[degrees]
10
1
0.1
6000
5000
4000
3000
2000
1000
0
10
100
1000


θ_{FWHM} [degrees]
10
1
0.1
6000
5000
4000
3000
2000
1000
0
10
100
1000
ℓ



θ_{rms} [degrees]
10
1
0.1
6000
5000
4000
3000
2000
1000
0
$\ell(\ell+1)C_\ell/2\pi$ [μK^2]
10
100
1000
ℓ


θ_{FWHM} [degrees]
10
1
0.1
6000
5000
4000
3000
2000
1000
0
$\ell(\ell+1)C_\ell/2\pi$ [μK^2]
10
100
1000
ℓ


θ_{cm} [degree]
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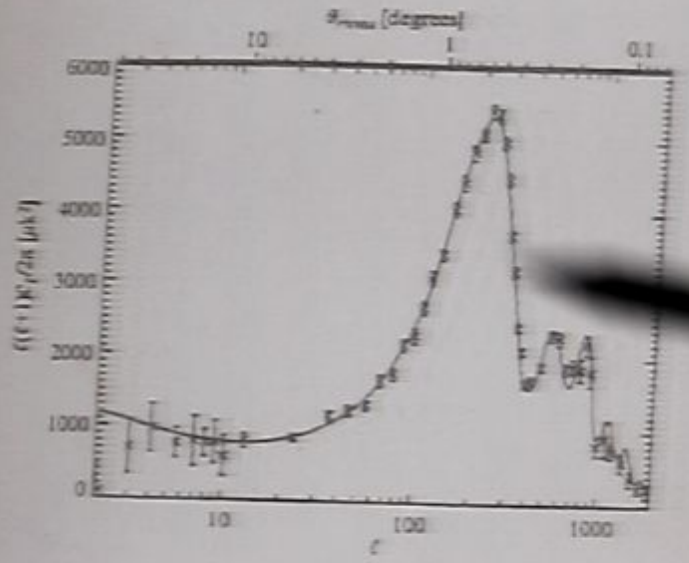
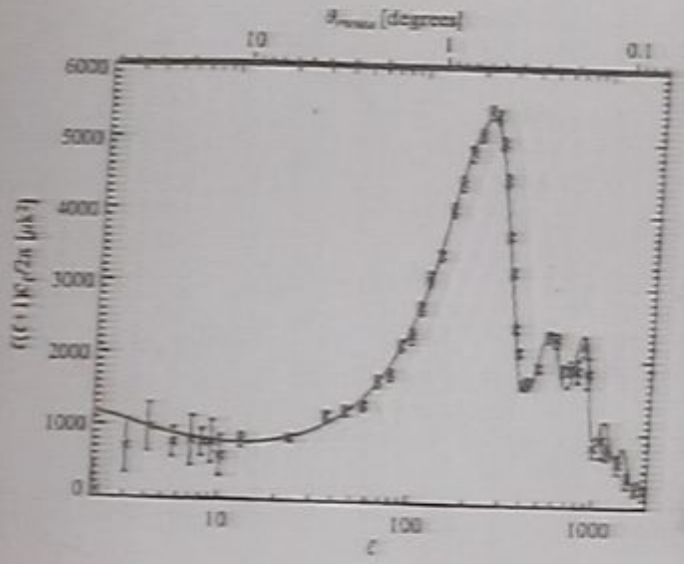
1
0.1
6000
5000
4000
3000
2000
1000
0
10
100
1000
ℓ

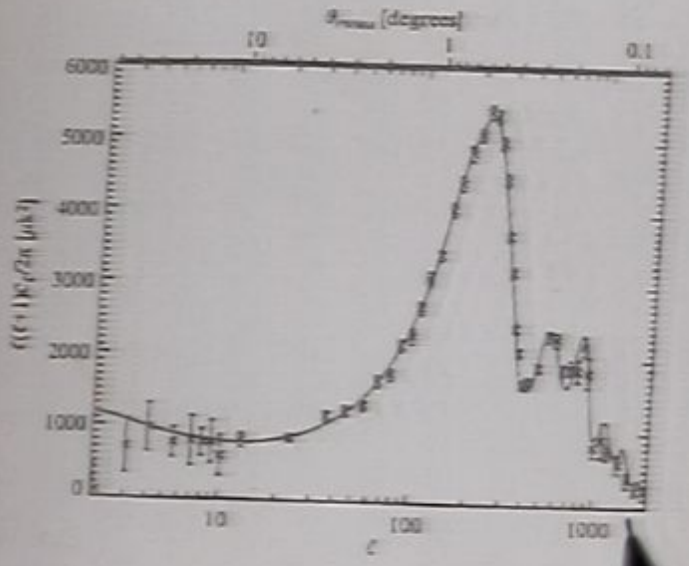

10
1
0.1
6000
5000
4000
3000
2000
1000
0
10
100
1000

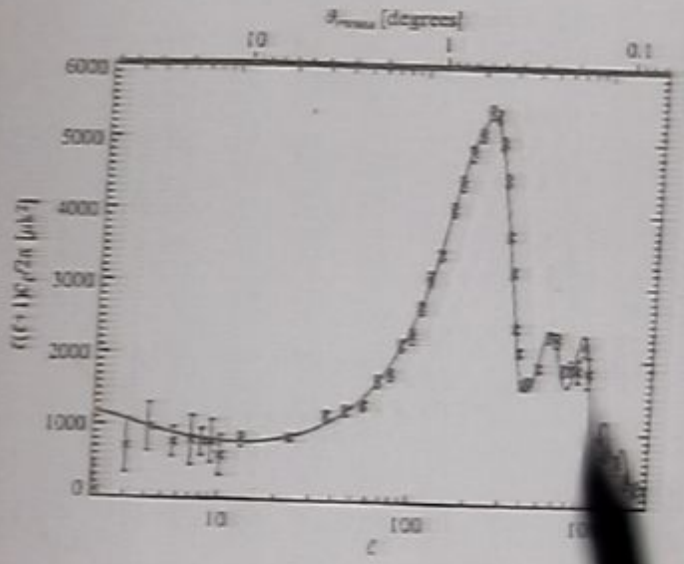
θ_{FWHM} [degrees]
10
1
0.1
6000
5000
4000
3000
2000
1000
0
10
100
1000
ℓ

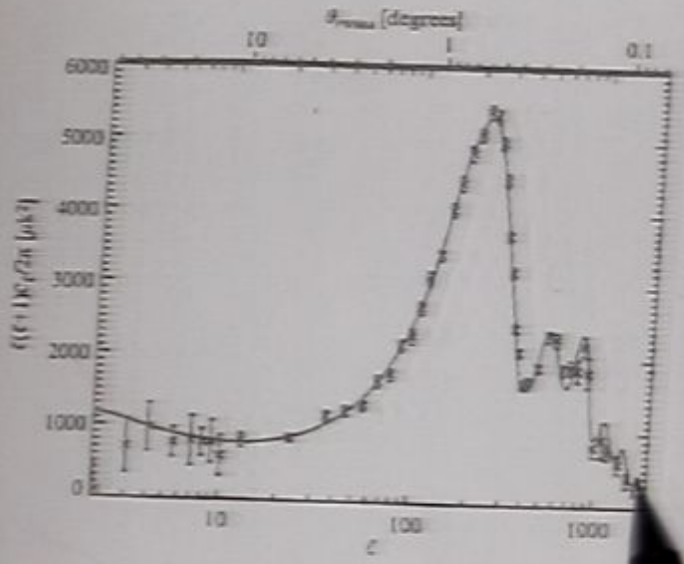

θ_{FWHM} [degrees]
10
1
0.1
6000
5000
4000
3000
2000
1000
0
$\ell(\ell+1)C_\ell/2\pi$ [μK^2]
10
100
1000
ℓ

$\theta_{measure}$ [degrees]
10
1
0.1
6000
5000
4000
3000
2000
1000
0
10
100
1000
ℓ

θ_{minima} [degrees]
10
1
0.1
6000
5000
4000
3000
2000
1000
0
10
100
1000
ℓ


θ_{FWHM} [degrees]
10
1
0.1
6000
5000
4000
3000
2000
1000
0
$\ell(\ell+1)C_\ell/2\pi$ [μK^2]
10
100
1000
ℓ


θ_{meas} [degrees]
10
1
0.1
6000
5000
4000
3000
2000
1000
0
10
100
ℓ


θ_{meas} [degrees]
10
1
0.1
6000
5000
4000
3000
2000
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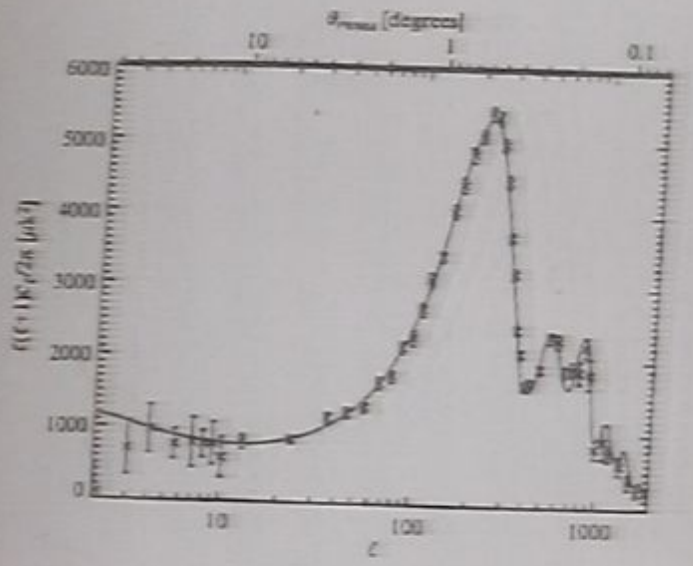
0
10
100
1000
C


θ_{FWHM} [degrees]
10
1
0.1
6000
5000
4000
3000
2000
1000
0
$\ell(\ell+1)C_\ell/2\pi$ [μK^2]
10
100
1000
ℓ

