

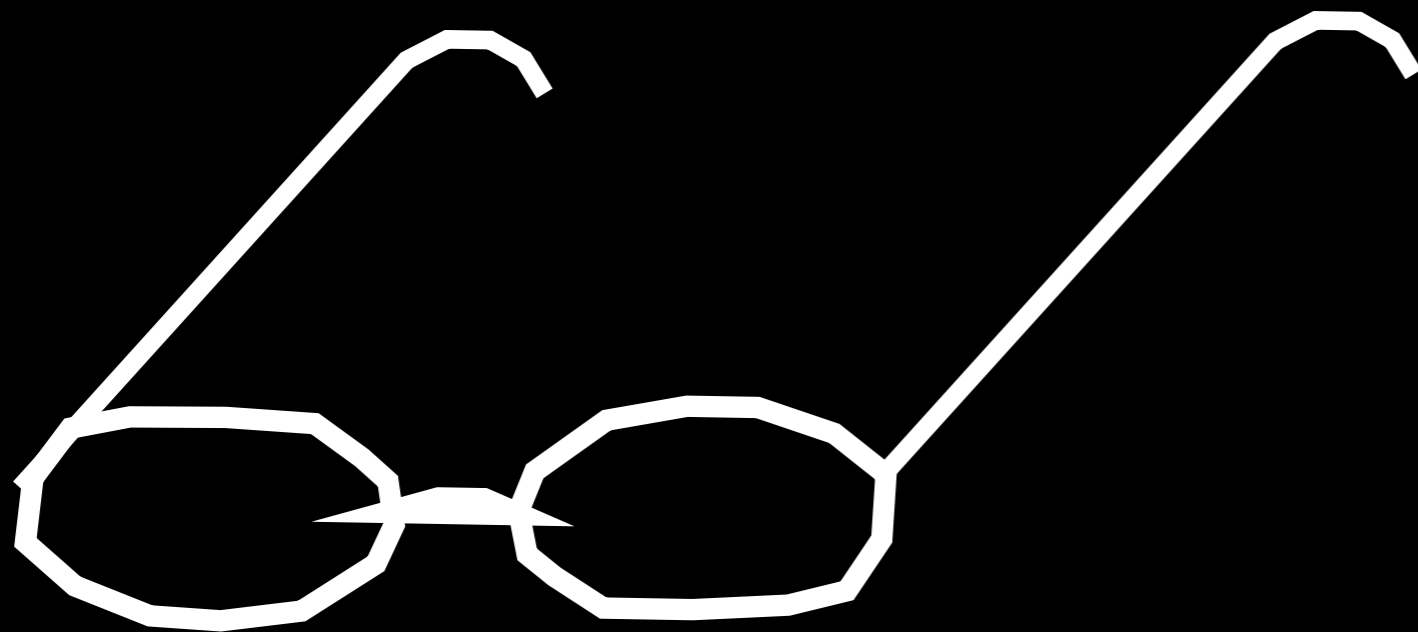
TEST

TEST

*TEST*



There remains ...  
the Earth's  
gravitational field



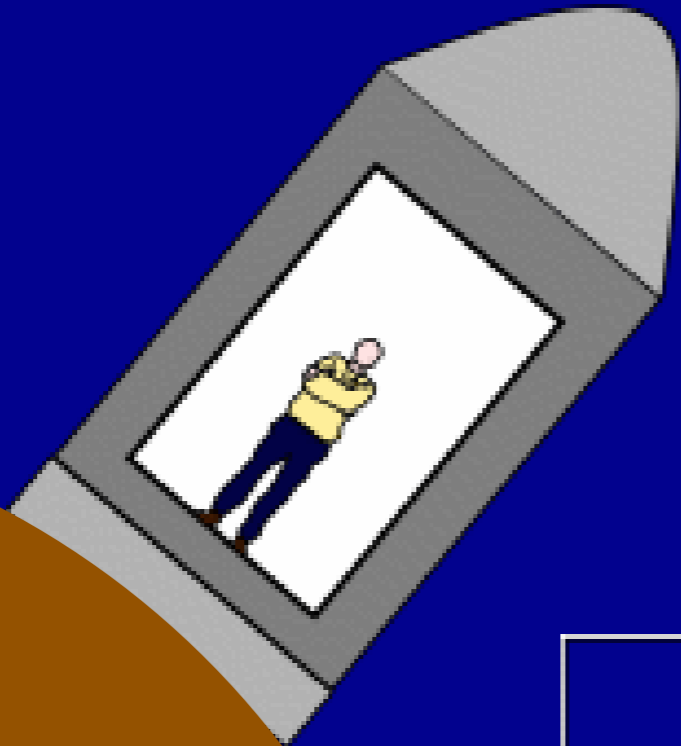
*Einstein*

~1906 -> 1916

?? ?? -> 1937



**Gravity**  
**=**  
**Acceleration**





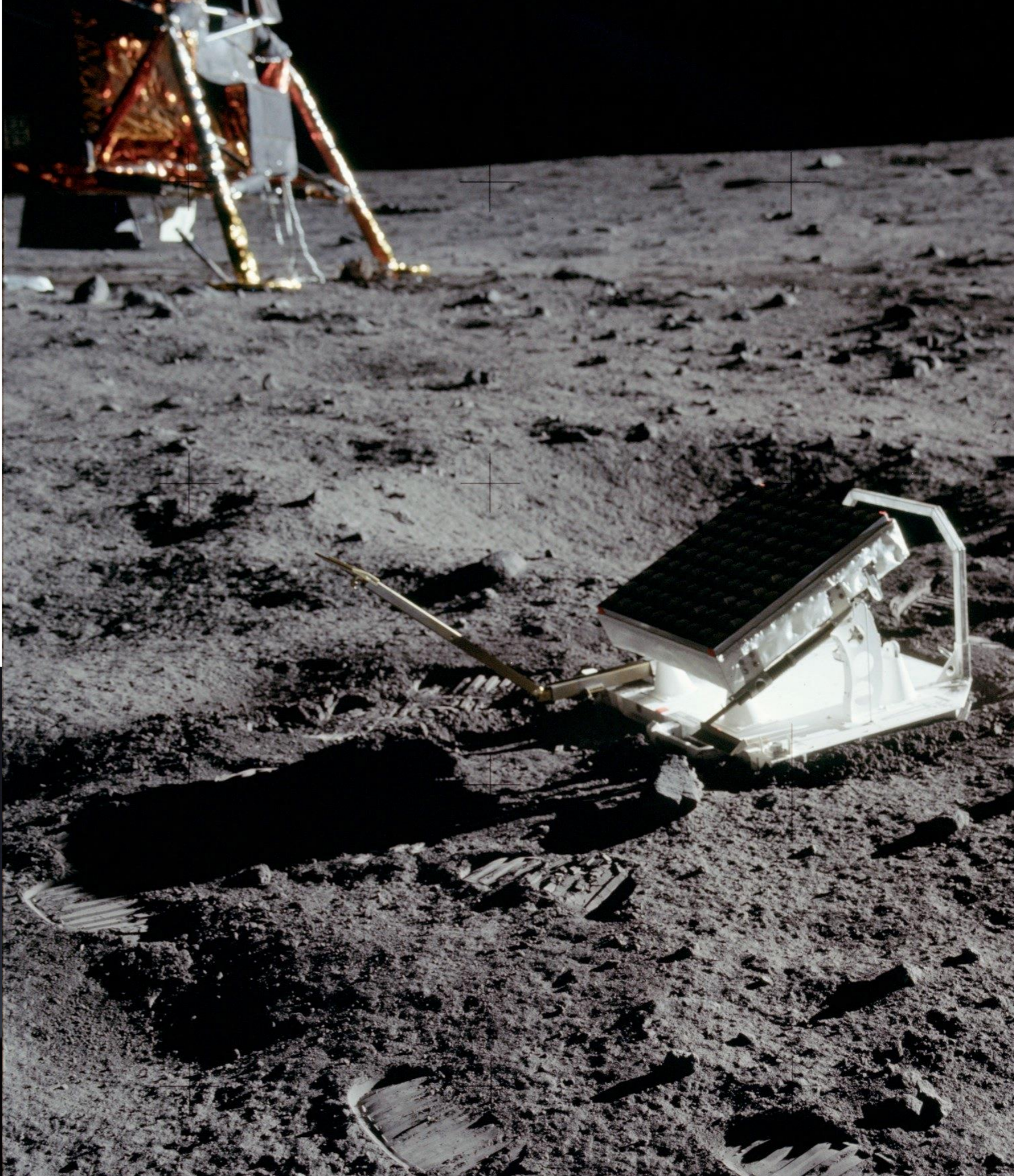




# Stan Wawrinka









Nordtvedt test

$$\delta g/g < 2 \times 10^{-13}$$

**P.E. Super-OK**

$$\Delta M \propto -\frac{GM^2}{R}$$

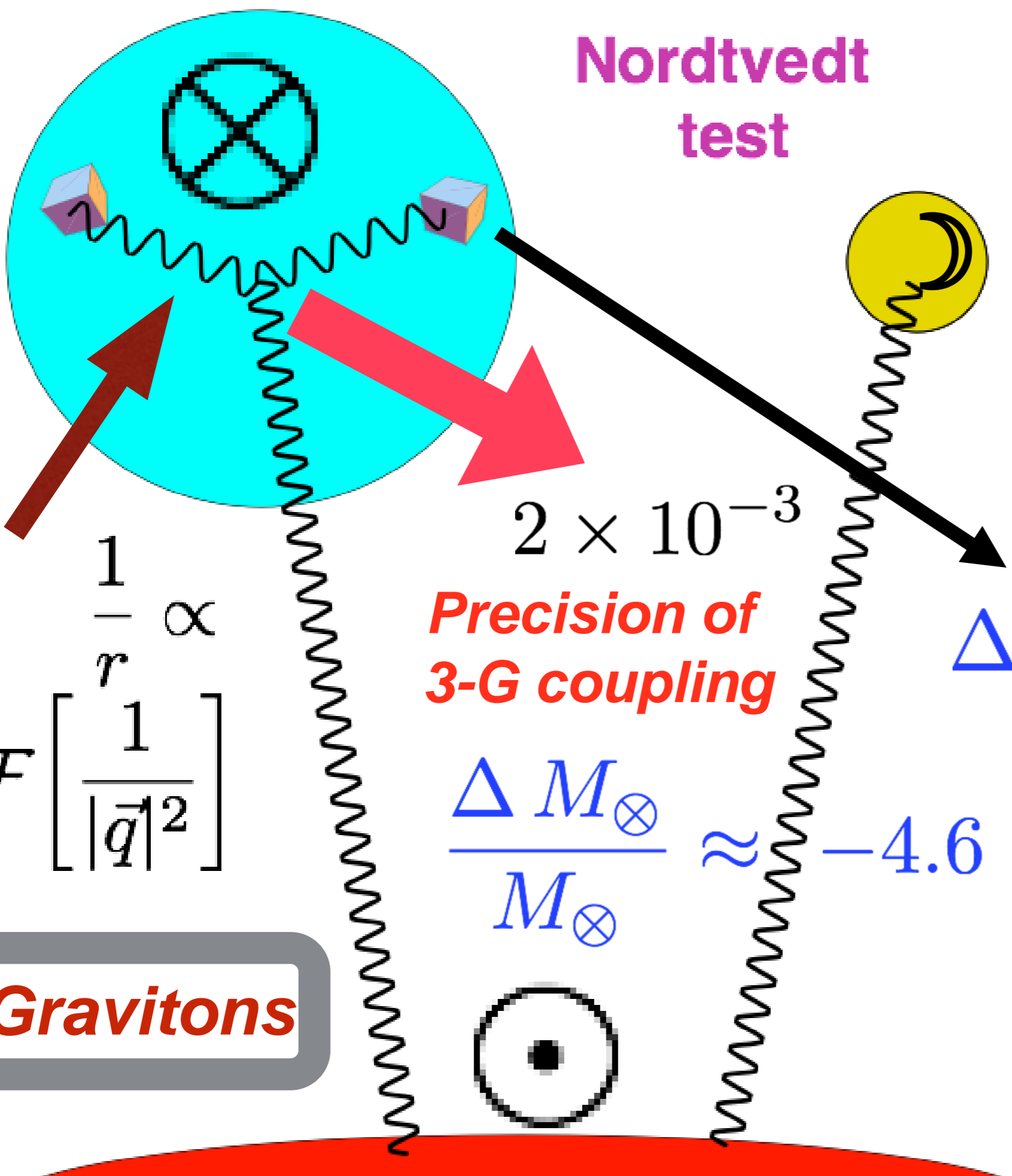
$2 \times 10^{-3}$   
**Precision of 3-G coupling**

$$\frac{\Delta M_{\otimes}}{M_{\otimes}} \approx -4.6 \times 10^{-10}$$

$$\frac{\Delta M_{\mu}}{M_{\mu}} \approx -2 \times 10^{-11}$$

$$\mathcal{F} \left[ \frac{1}{r} \propto \frac{1}{|\vec{q}|^2} \right]$$

**Gravitons**



# ***SOLUTIONS to Einstein's GR equations***

**Proper working of GPS clocks**

***Mercury's Perihelion advance (post-diction)***

**GR model of the solar system**

***Deflection and time-delay of light signals***

**The orbits of binary pulsar(s)**

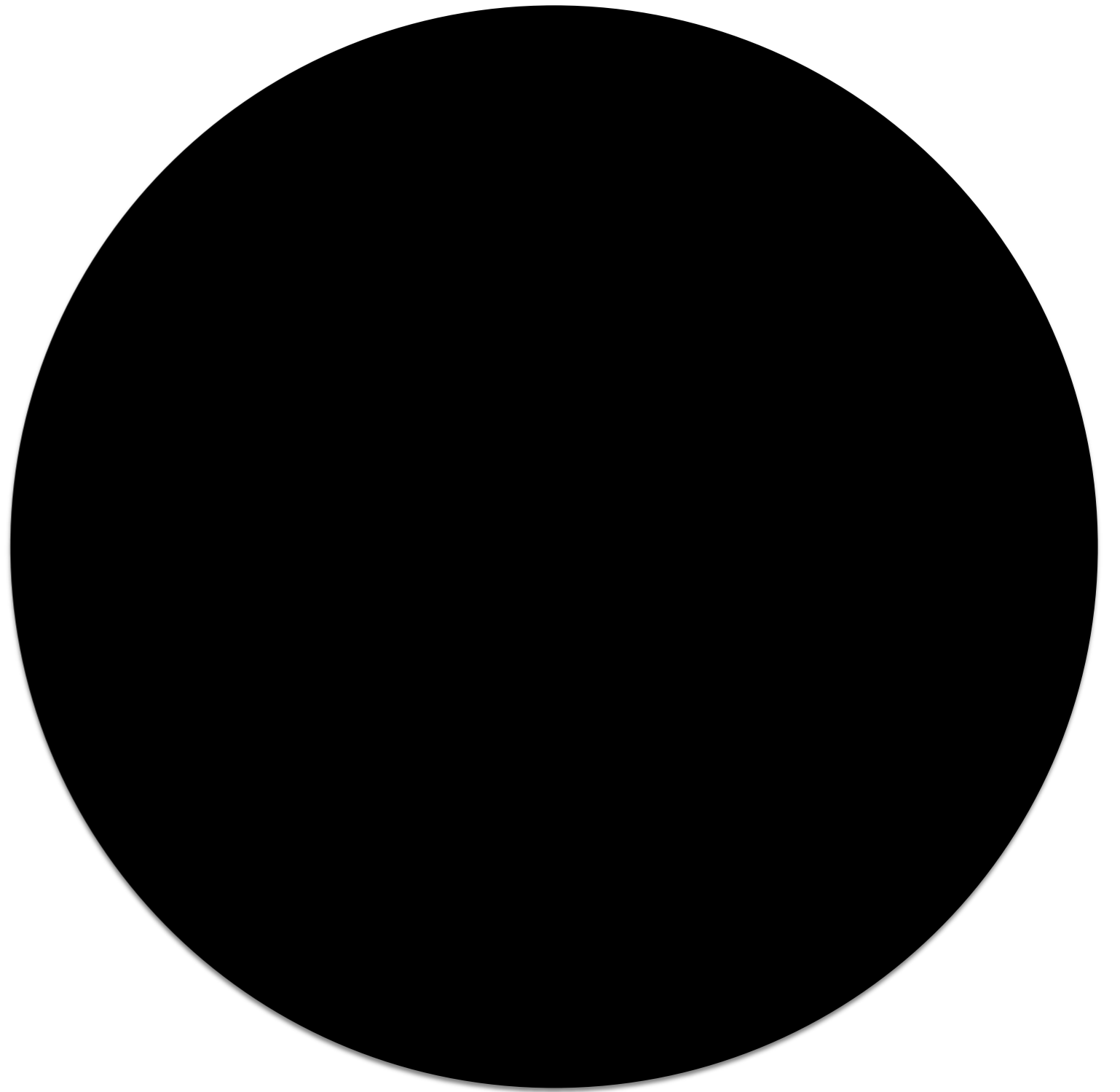
***[the discovery of gravitational waves]***

**Black Holes**

***The standard model of the Universe  
(overall + dozens of details)***







+

**G.Ws**

## ON A STATIONARY SYSTEM WITH SPHERICAL SYMMETRY CONSISTING OF MANY GRAVITATING MASSES

BY ALBERT EINSTEIN

(Received May 10, 1939)

The essential result of this investigation is a clear understanding as to why the "Schwarzschild singularities" do not exist in physical reality. Although the theory given here treats only clusters whose particles move along circular paths it does not seem to be subject to reasonable doubt that more general cases will have analogous results. The "Schwarzschild singularity" does not appear for the reason that matter cannot be concentrated arbitrarily. And this is due to the fact that otherwise the constituting particles would reach the velocity of light.





The  
dream  
of  
reason  
creates  
monsters



$$\frac{2GM}{R} > 1$$



**Event  
Horizon**

# El Castillo de Irás y no Volverás





**In 1936, Einstein  
and Nathan Rosen**

**sent a paper to**

**Physical Review in**

**which they claimed**

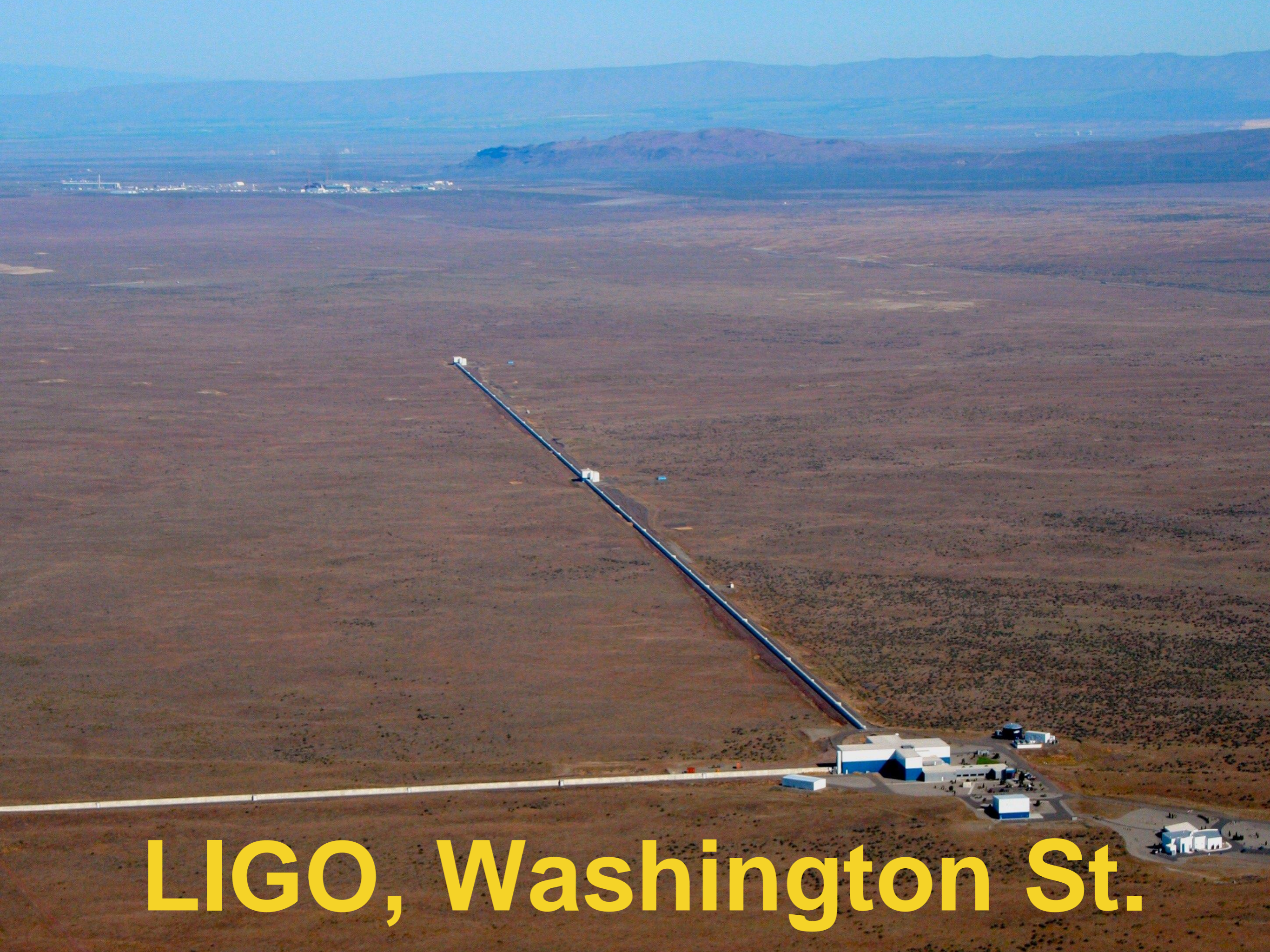
**GWs** could not exist





# LIGO, Louisiana





**LIGO, Washington St.**

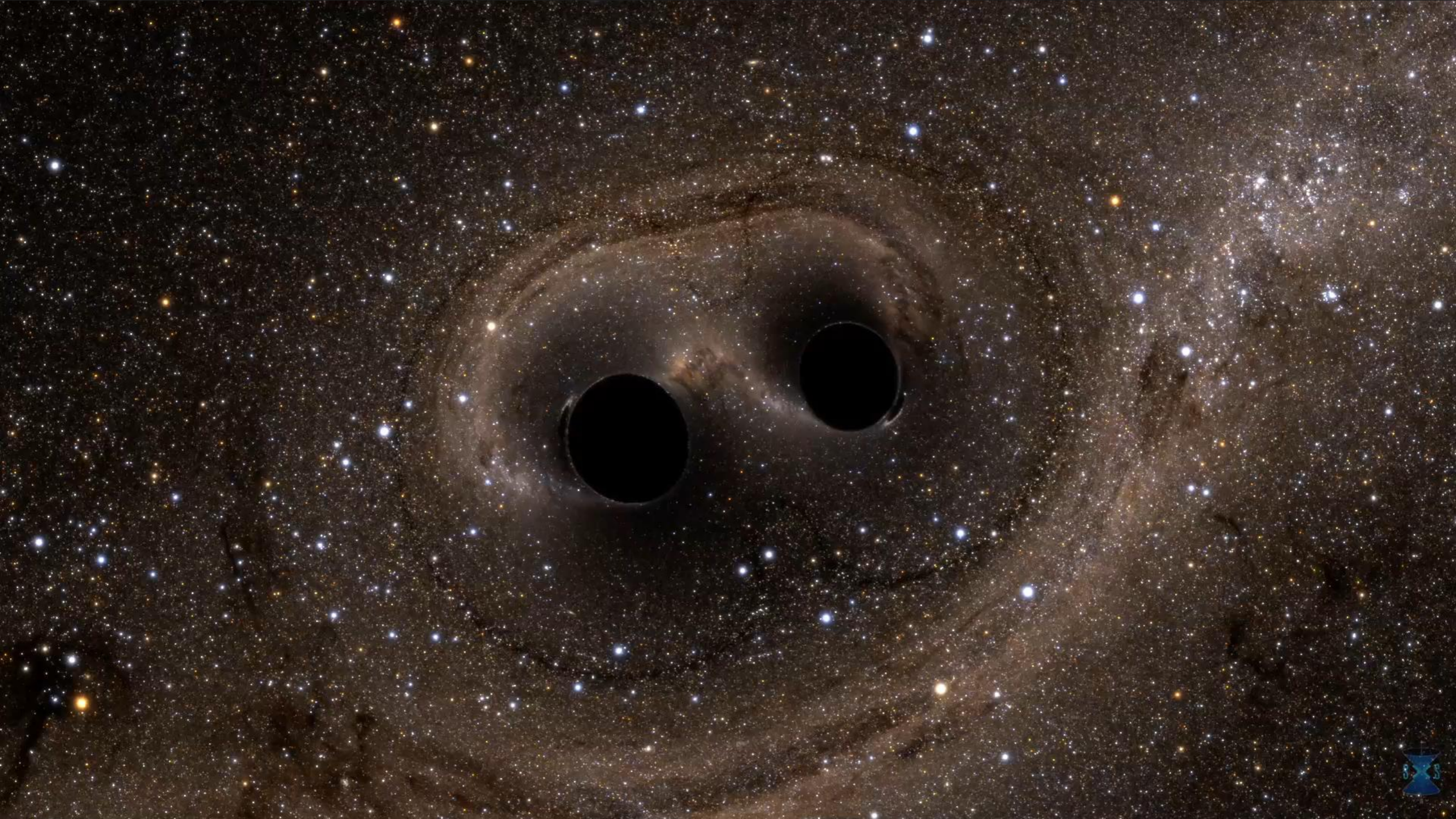








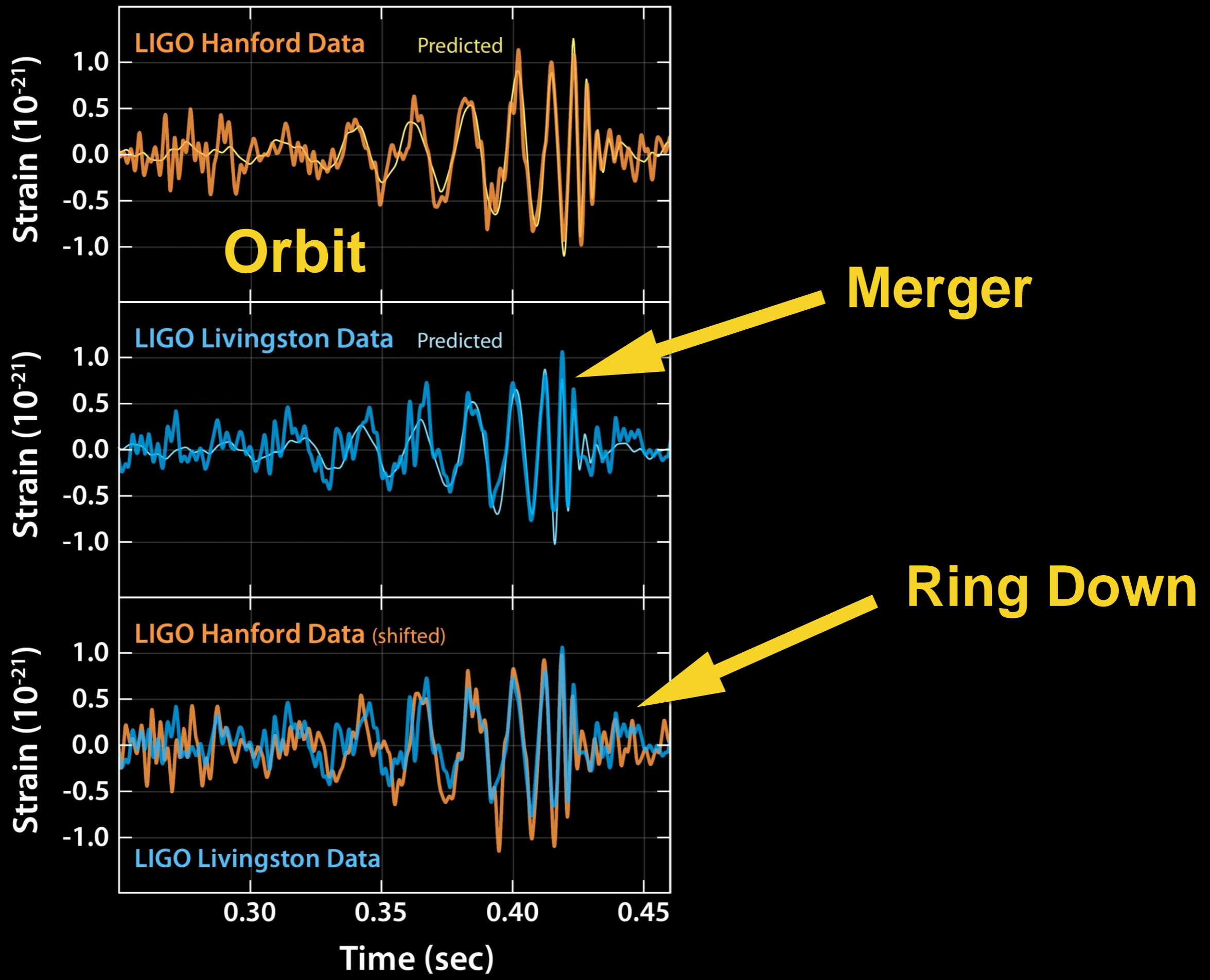
*ONCE UPON A TIME ...*



*15 million centuries ago*









1

2

3



Time



Most convincing  
evidence for the  $\dot{E}$  of  
***BLACK HOLES***

**BEST TEST** of GR in  
“**STRONG-FIELD** regime”



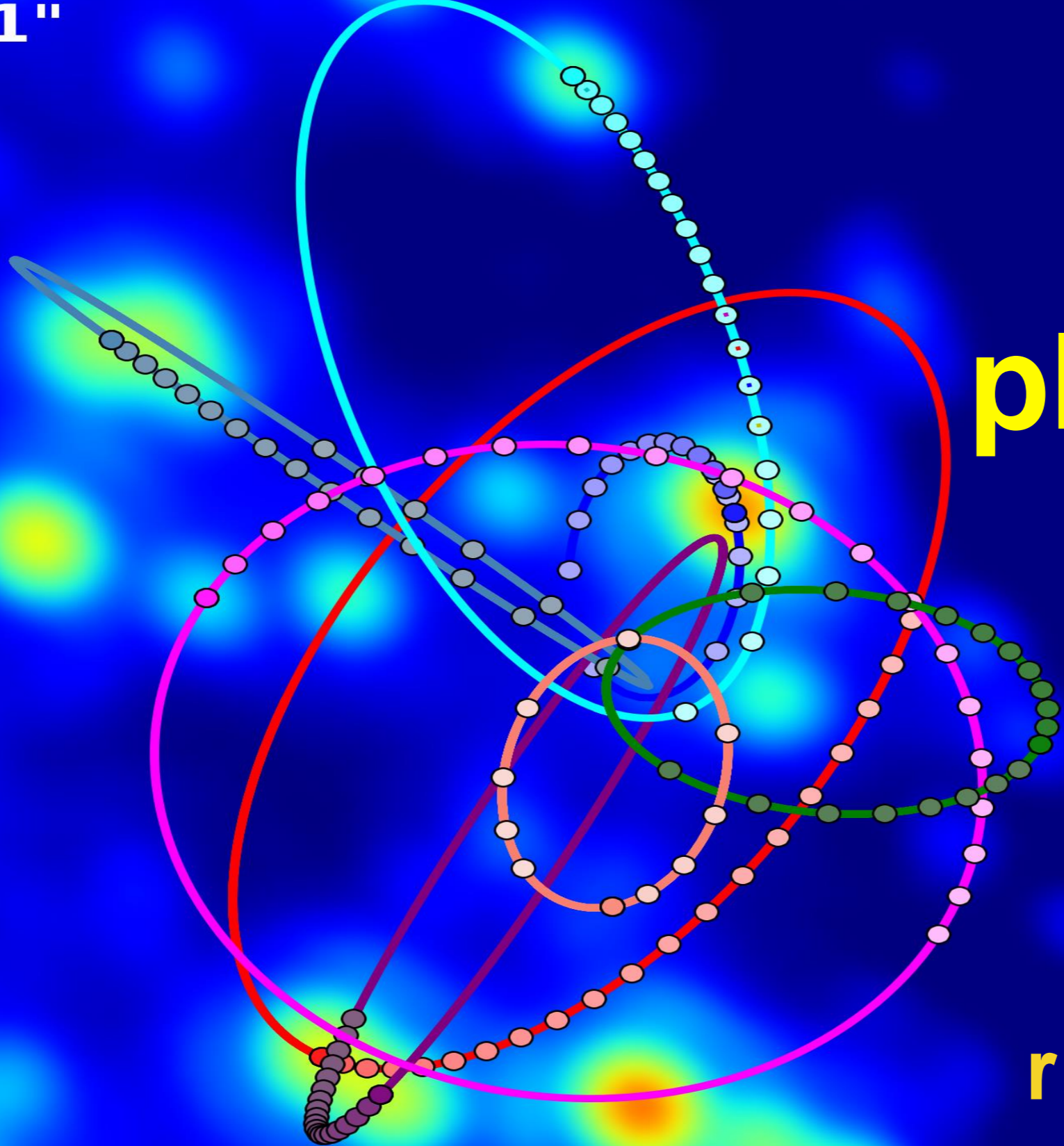


0.1"

Back  
to

photons

- S0-1
- S0-2
- S0-5
- S0-16
- S0-19
- S0-20
- S0-38
- S0-102



$r < 0.002 \text{ ly}$

$M_{BH?} = 4.3 \times 10^6 M_{\odot}$

Keck/UCLA  
Galactic Center Group

1995-2014



V

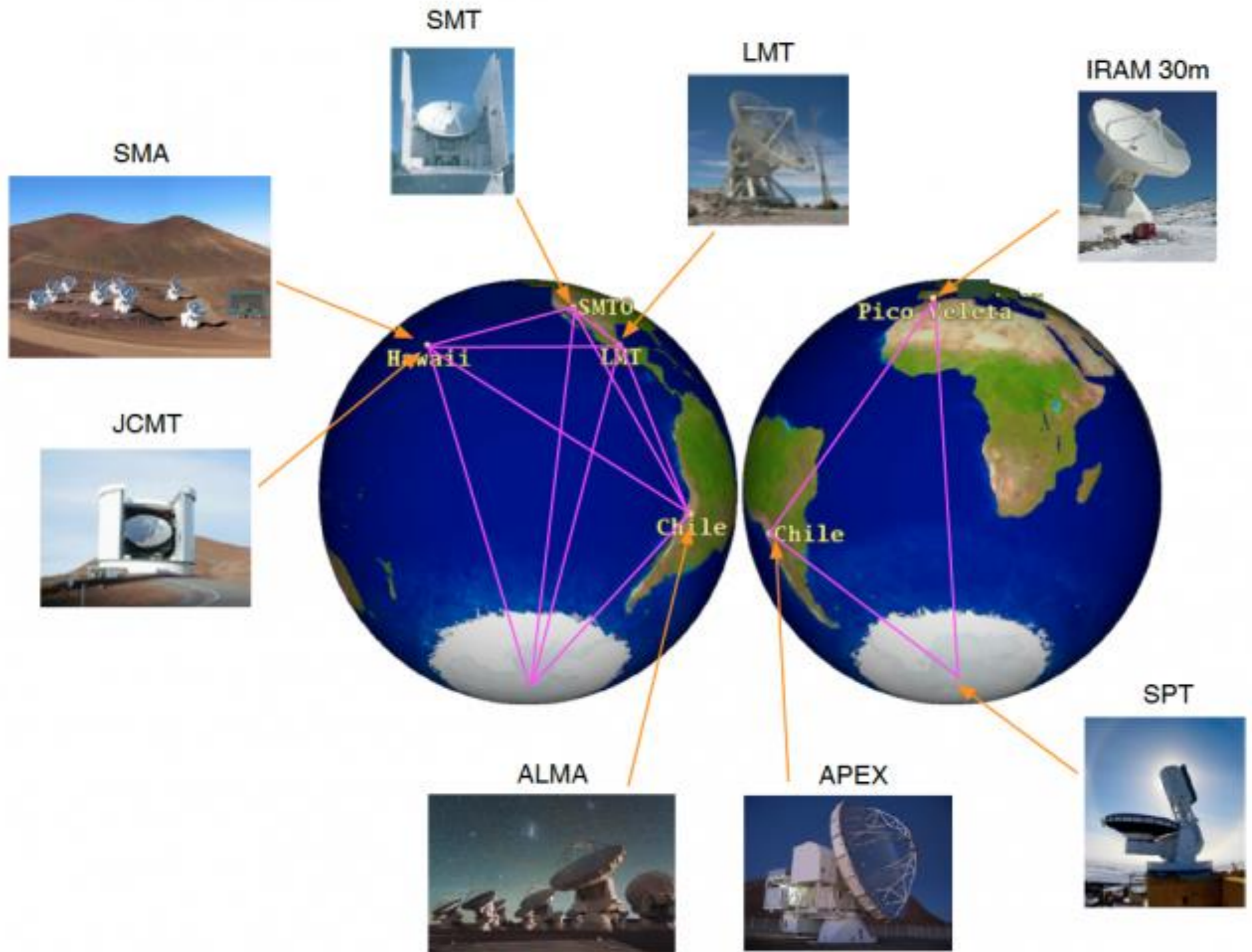
L

B

I











$5 r_s$

Low  
Resolution

Higher  
Resolution

“Shadow”

Simulation



**Merriam-Webster  
Dictionary (def. 1a)**

***Simulate (vb):***

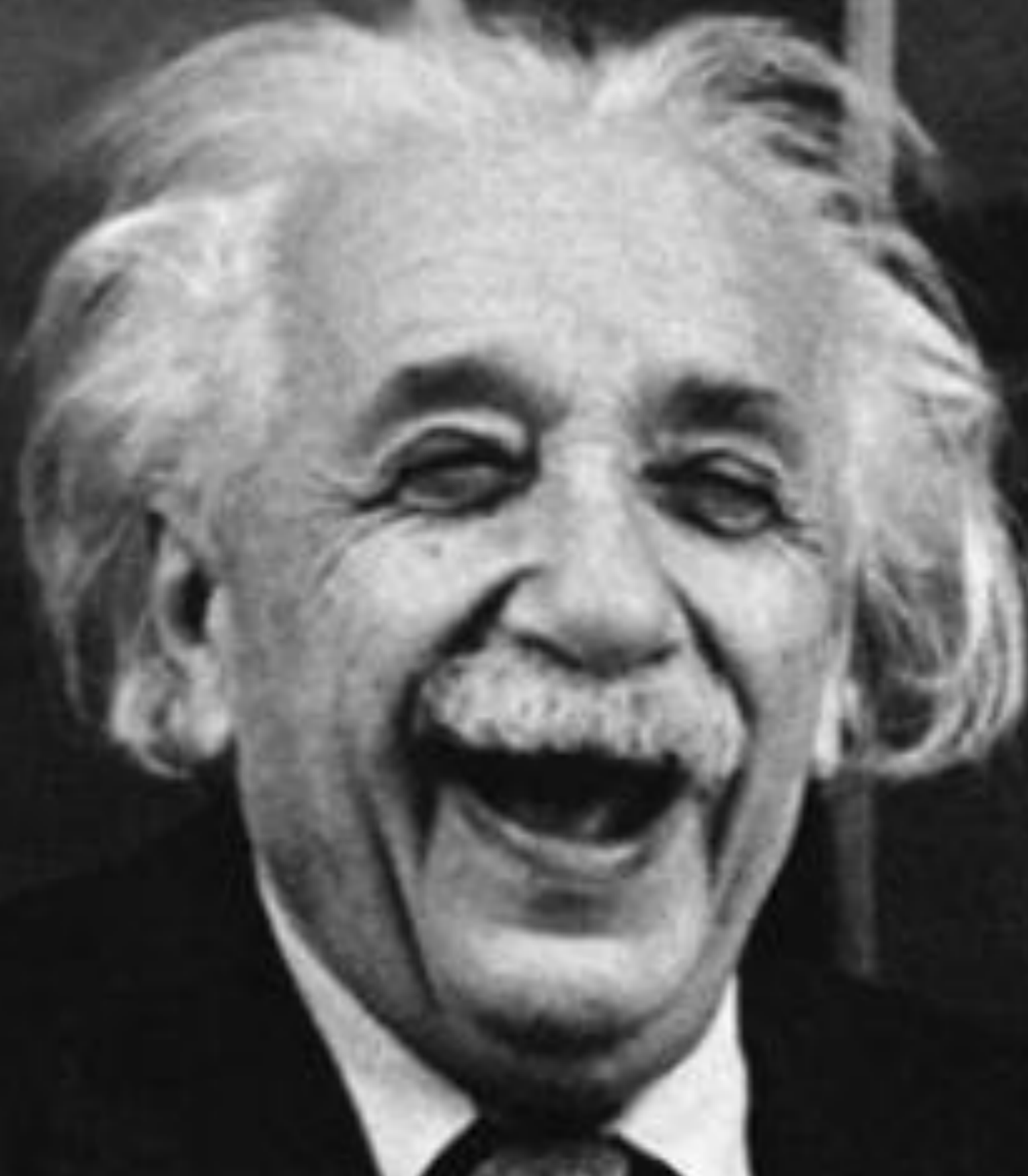
**To give or assume the  
appearance or effect of  
something, often with  
the intent to deceive ...**





**The “shadow” of the  
Black Hole in M87**





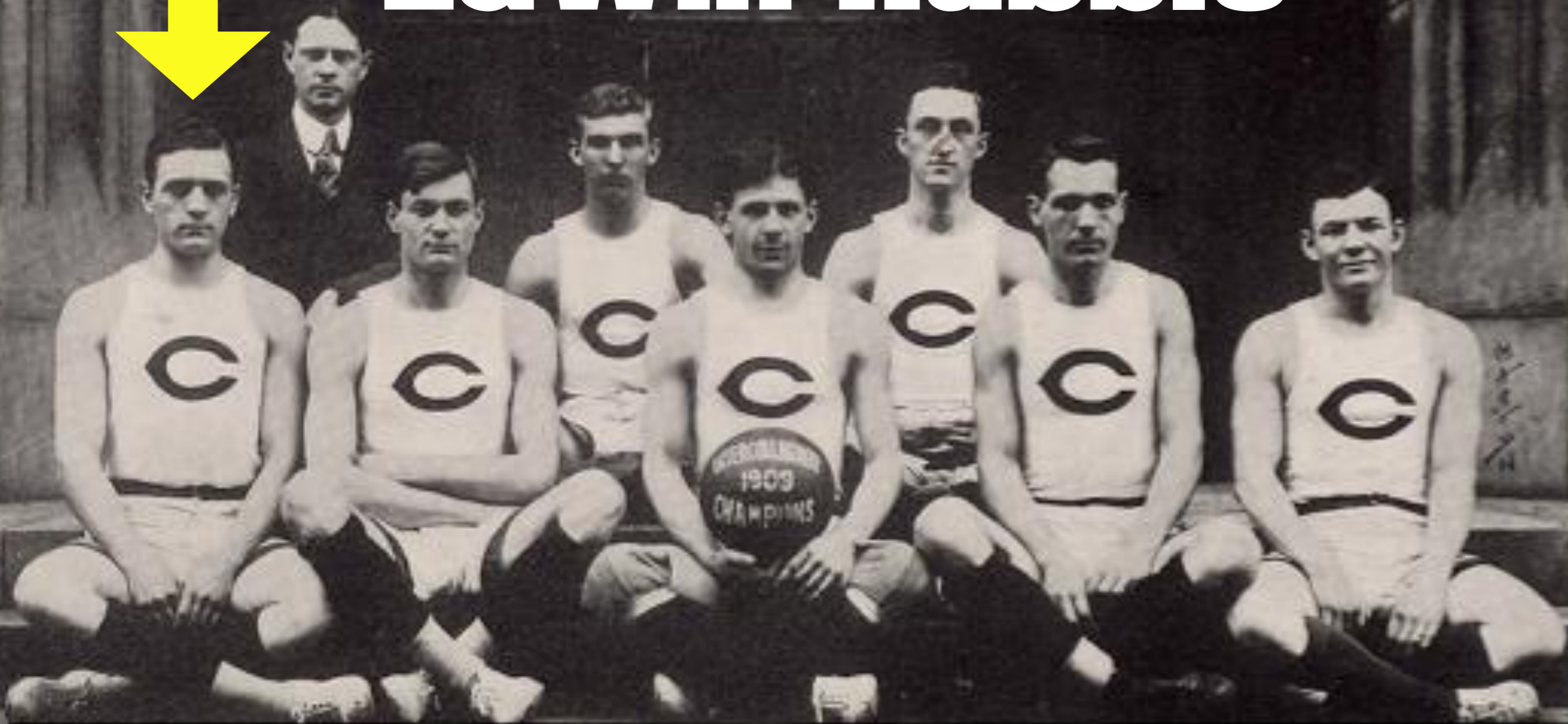


1/2



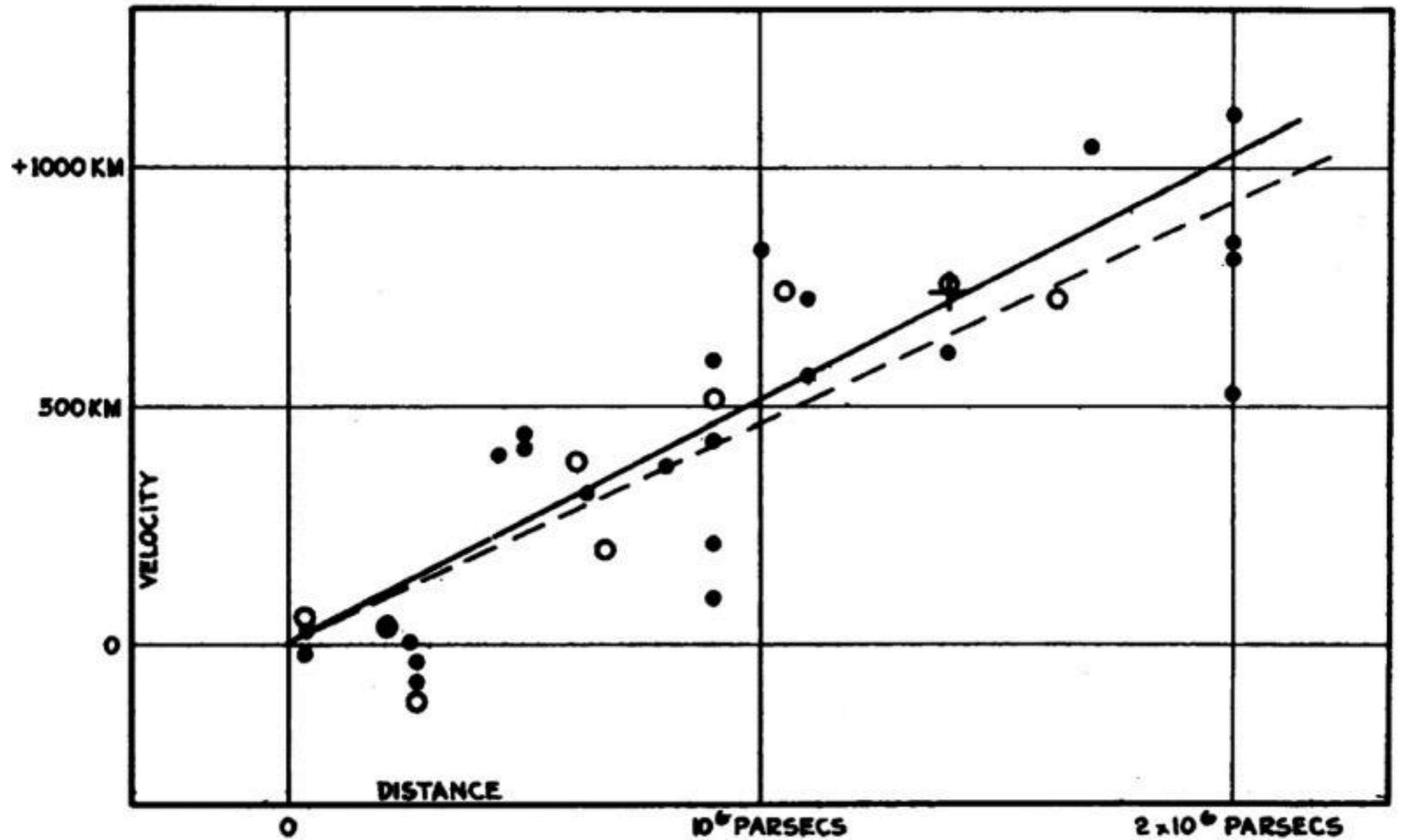


# Edwin Hubble





Velocity-Distance Relation among Extra-Galactic Nebulae.



**Slipher, Hubble & Lemaître**



# Hubbly plot Type Ia SNe

$$\Omega \equiv \frac{\rho[\text{observed}]}{\rho[\text{critical}]}$$

$$\Omega = 1 \text{ "Critical"}$$

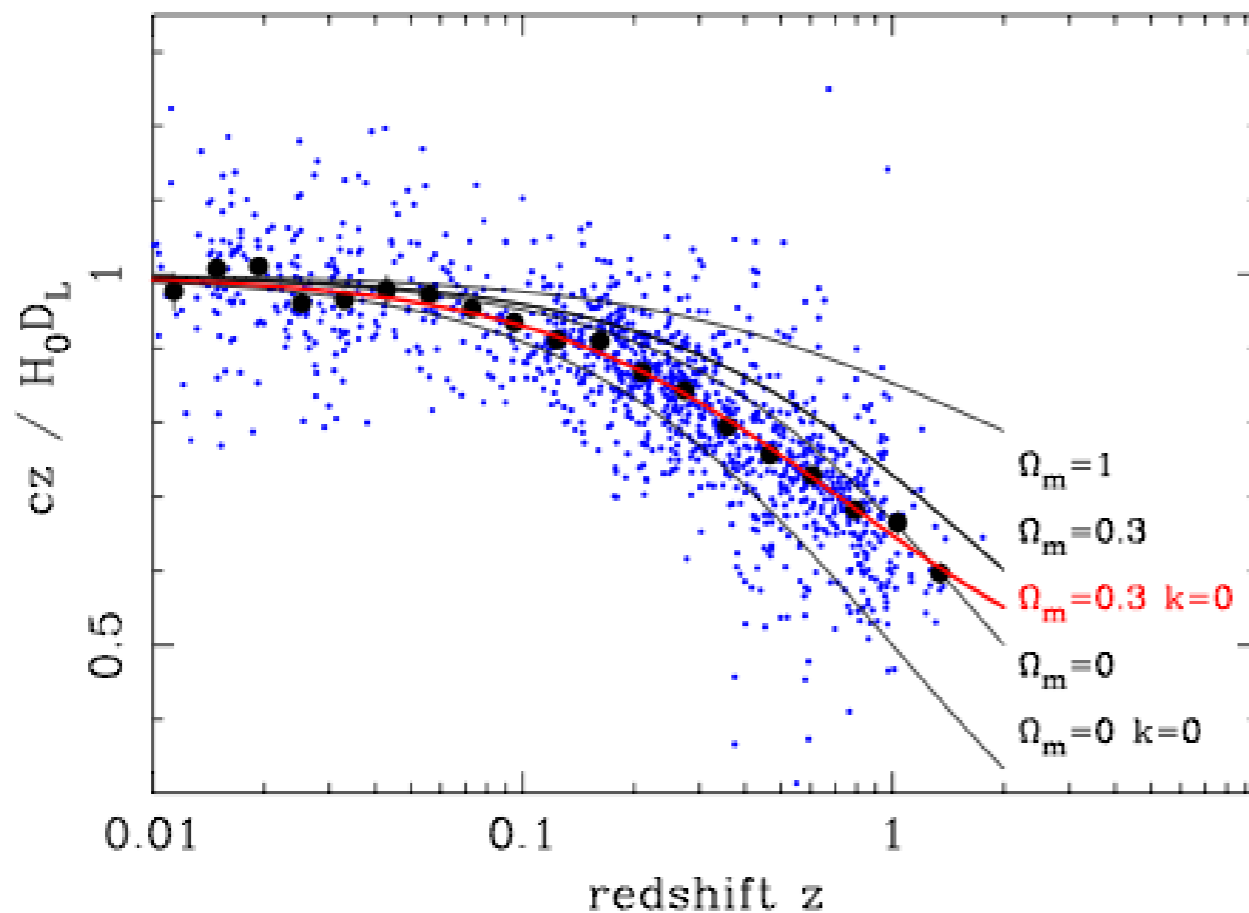
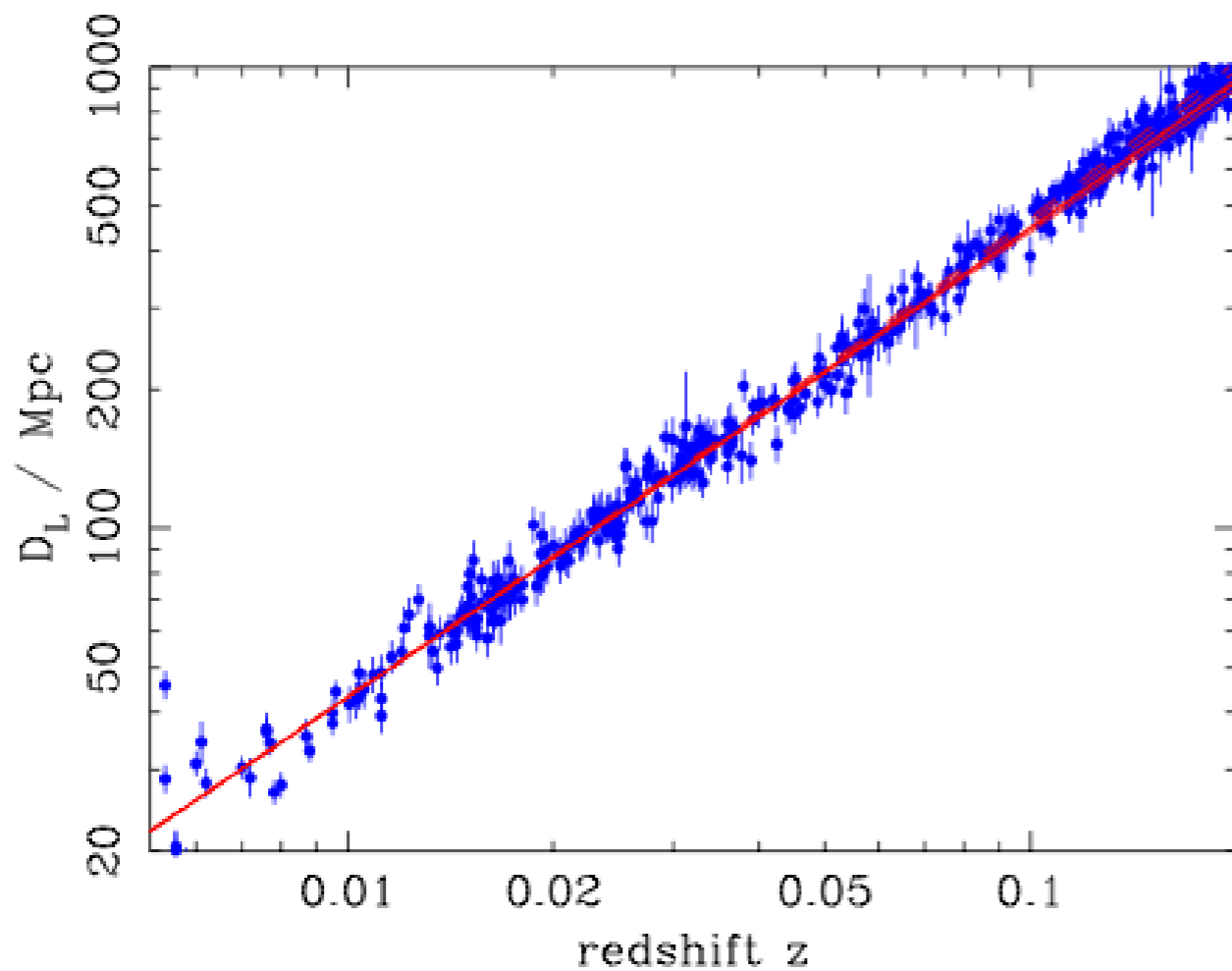
**Critical  $\leftrightarrow$  3D flat**

**Best Fit**

$$|\Omega - 1| < 0.007$$

$$\Omega_M \approx 0.3$$

$$\Omega_\Lambda \approx 0.7$$





G.R.

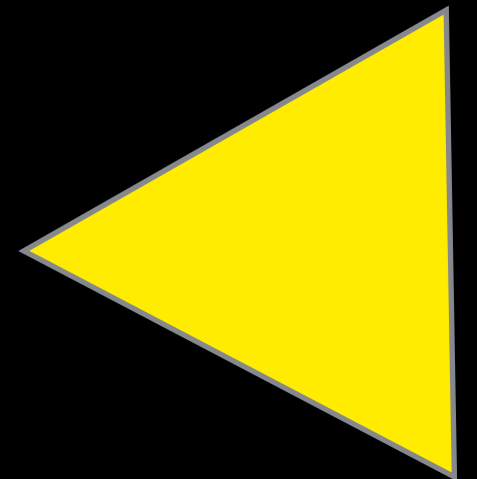
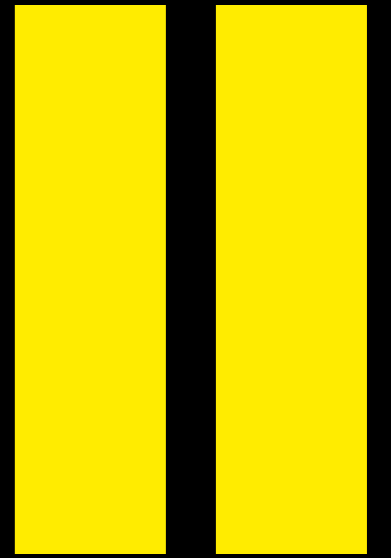
H.E.P.



AL

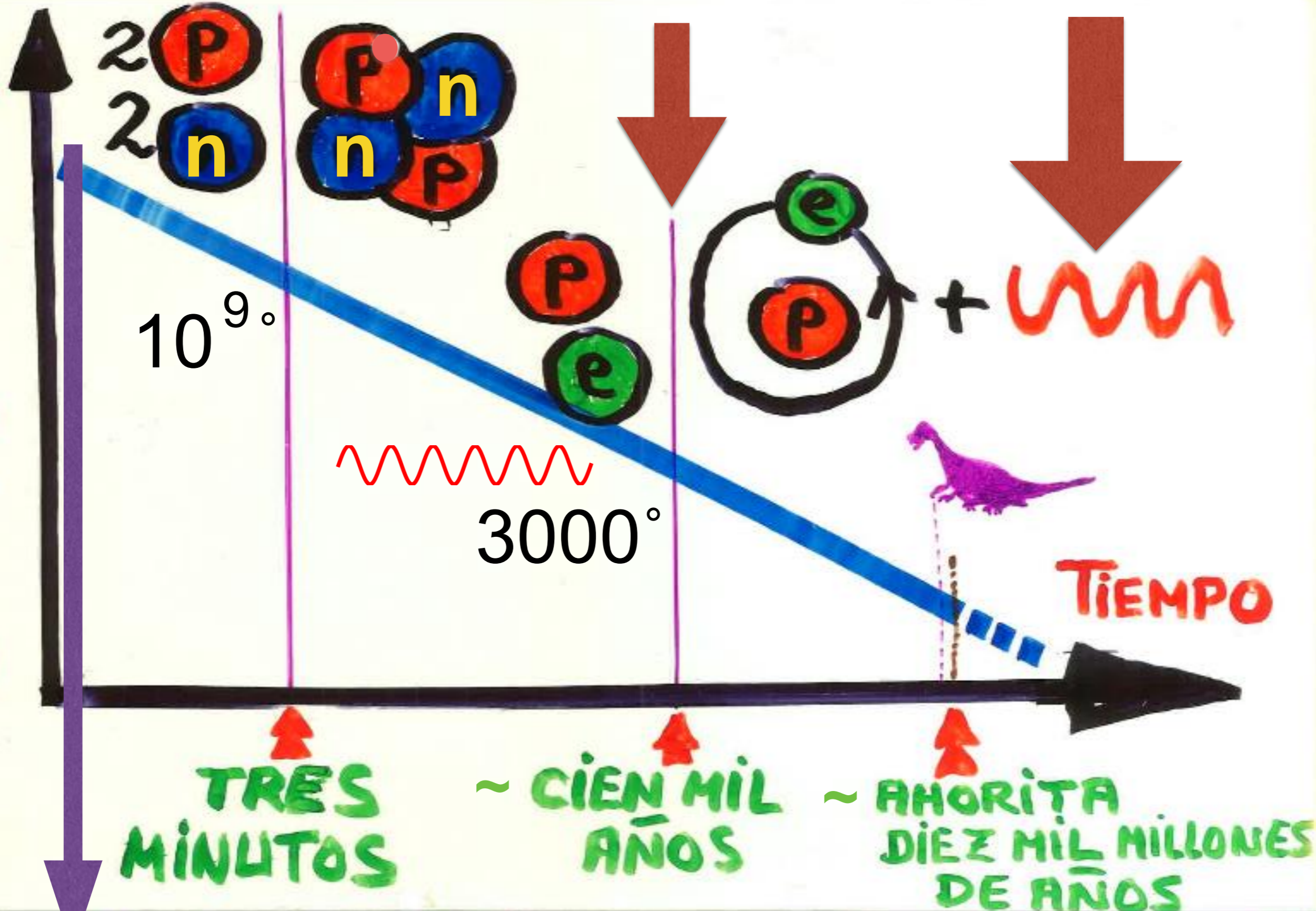


**How  
things  
work,  
e.g. at  
CERN**





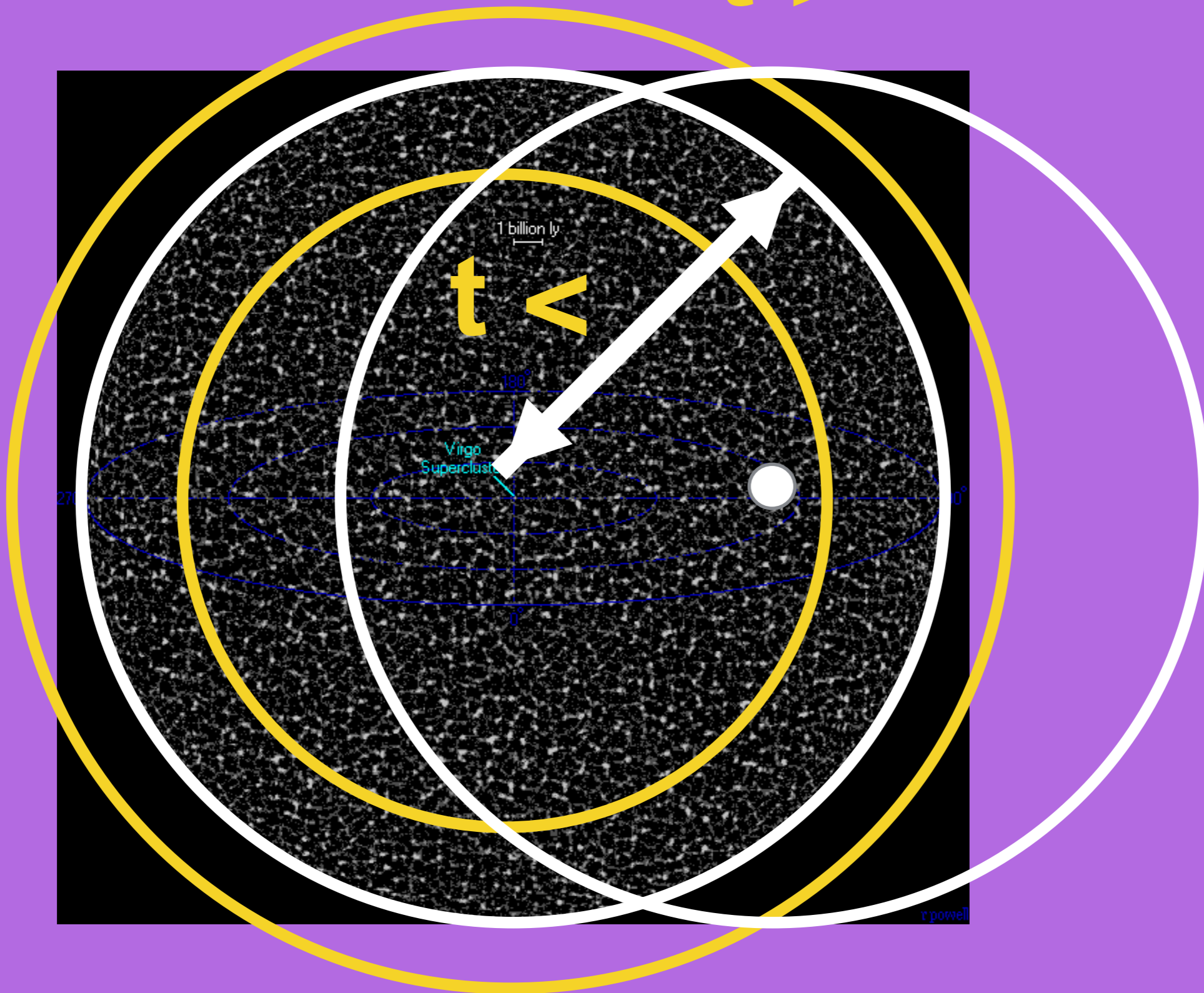
TEMPERATURA



EDAD del Universo  $t(E = 10 \text{ TeV}) = 10$  segundos  
 $10^{14}$

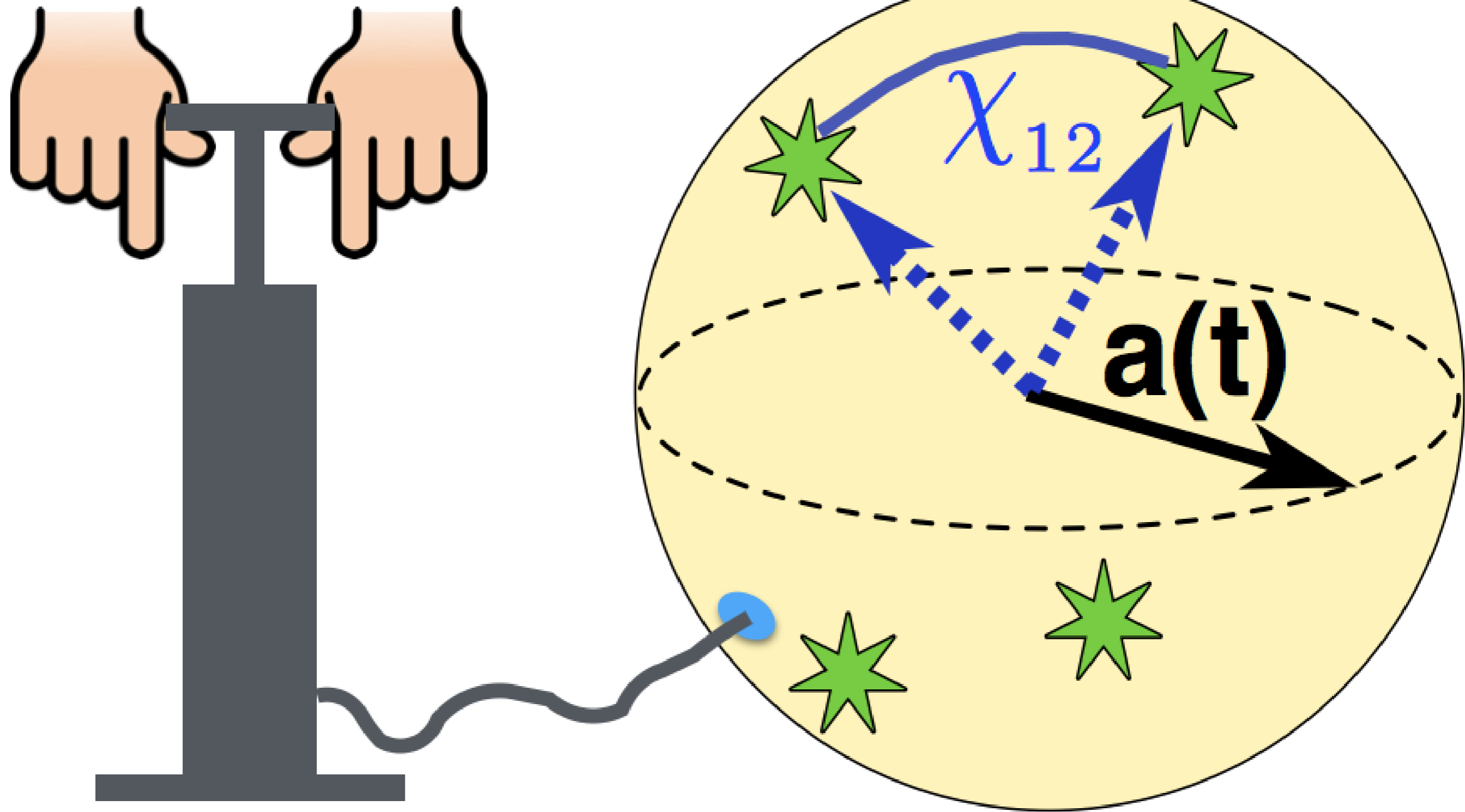


$t >$



$z \sim 1300$





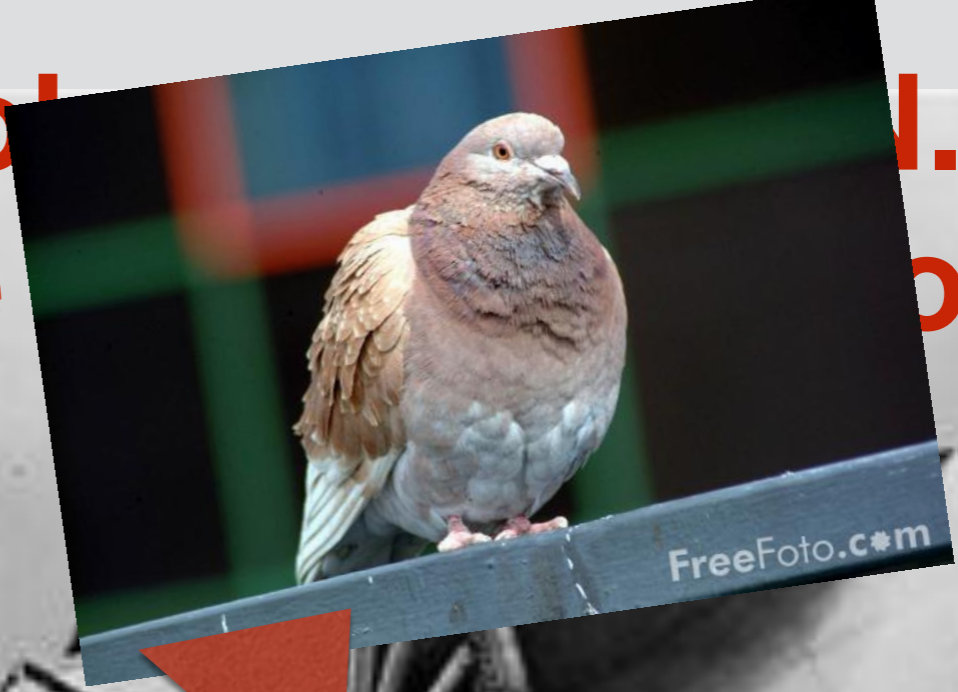
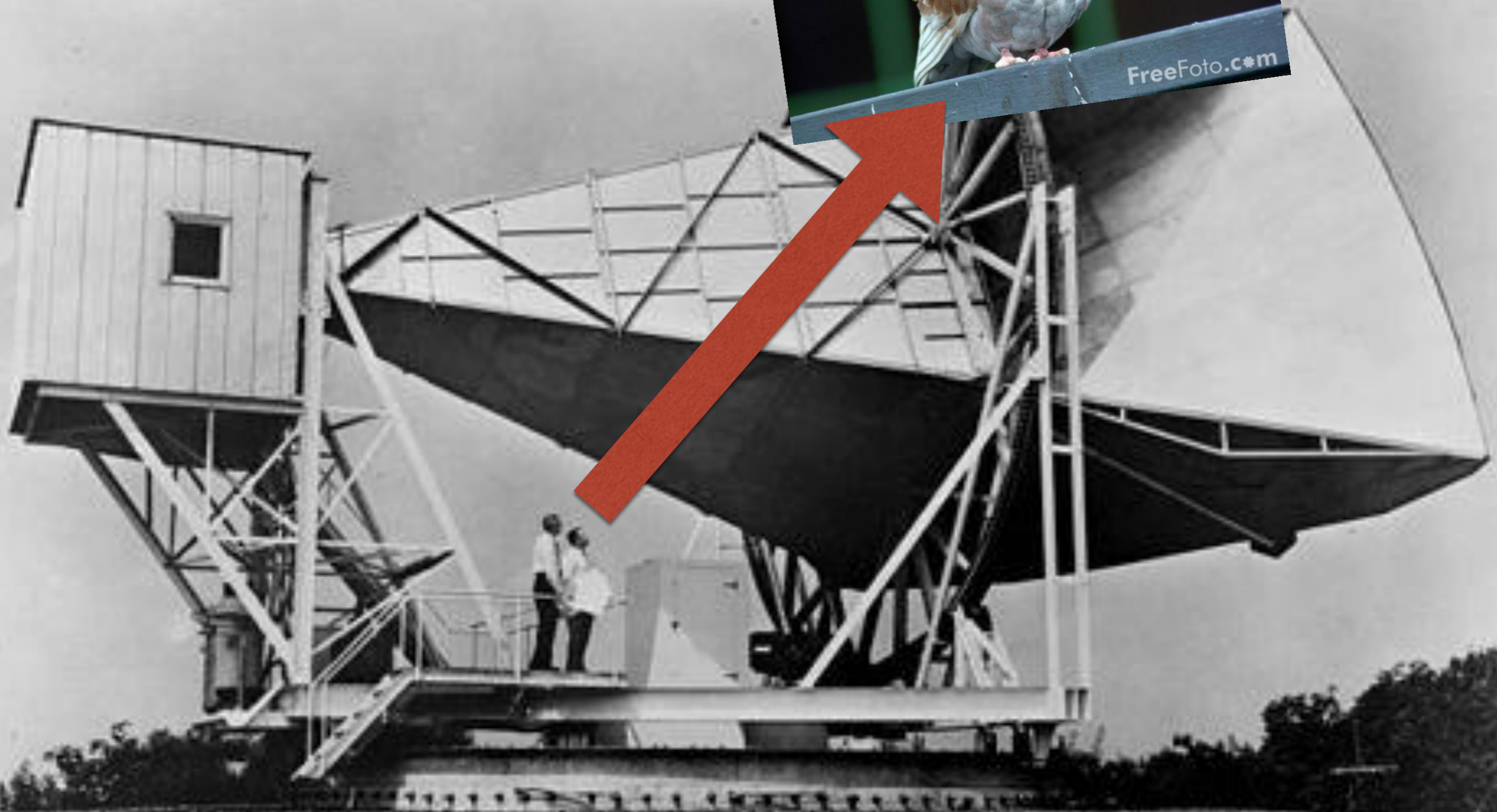
**Space between distant galaxies**

relative to

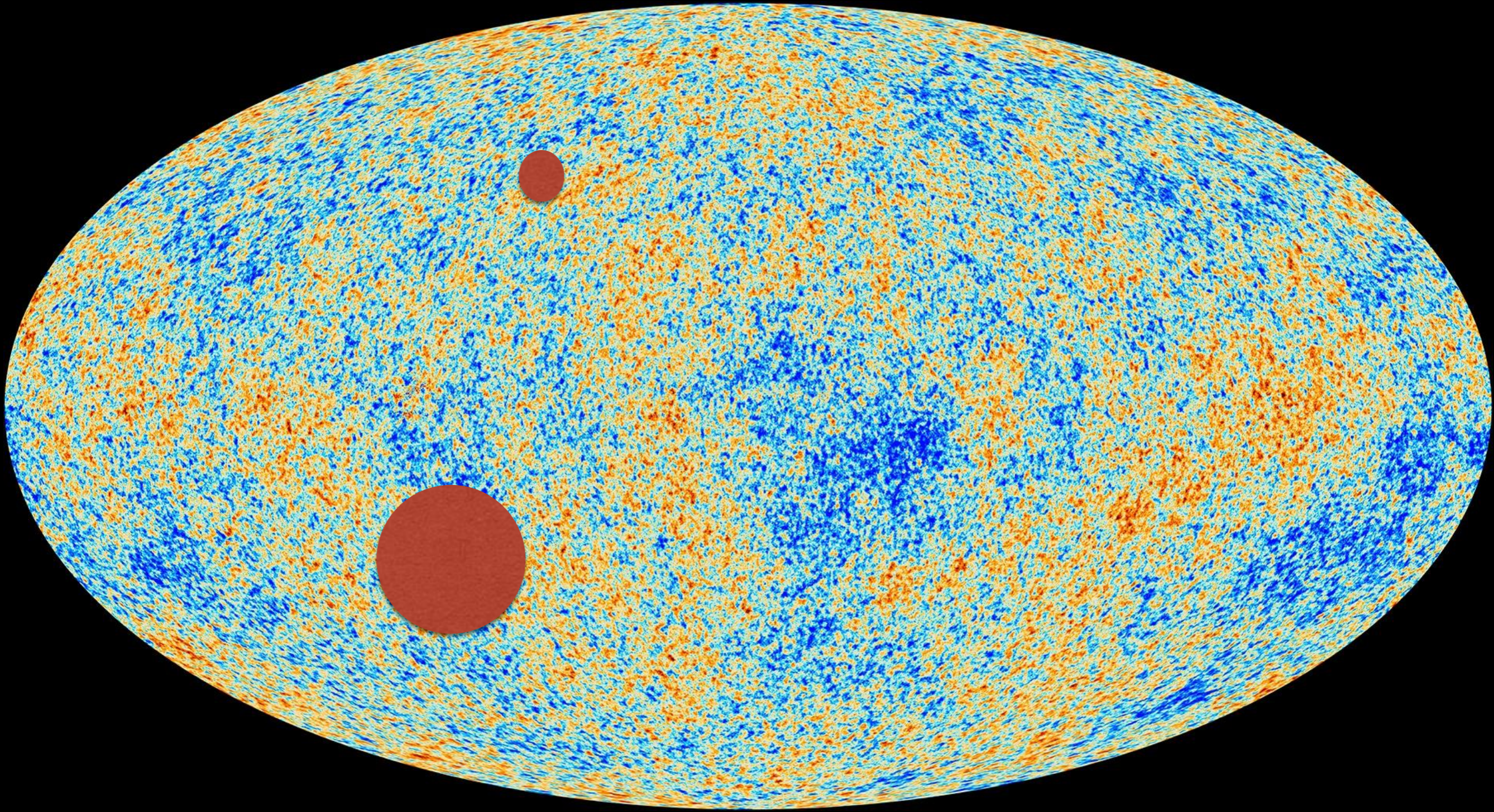
**Size of a H atom after  $e + p \rightarrow H$**



# Arno Penzias & Robert Woodrow Wilson Bell Labs. Satellite Antennas







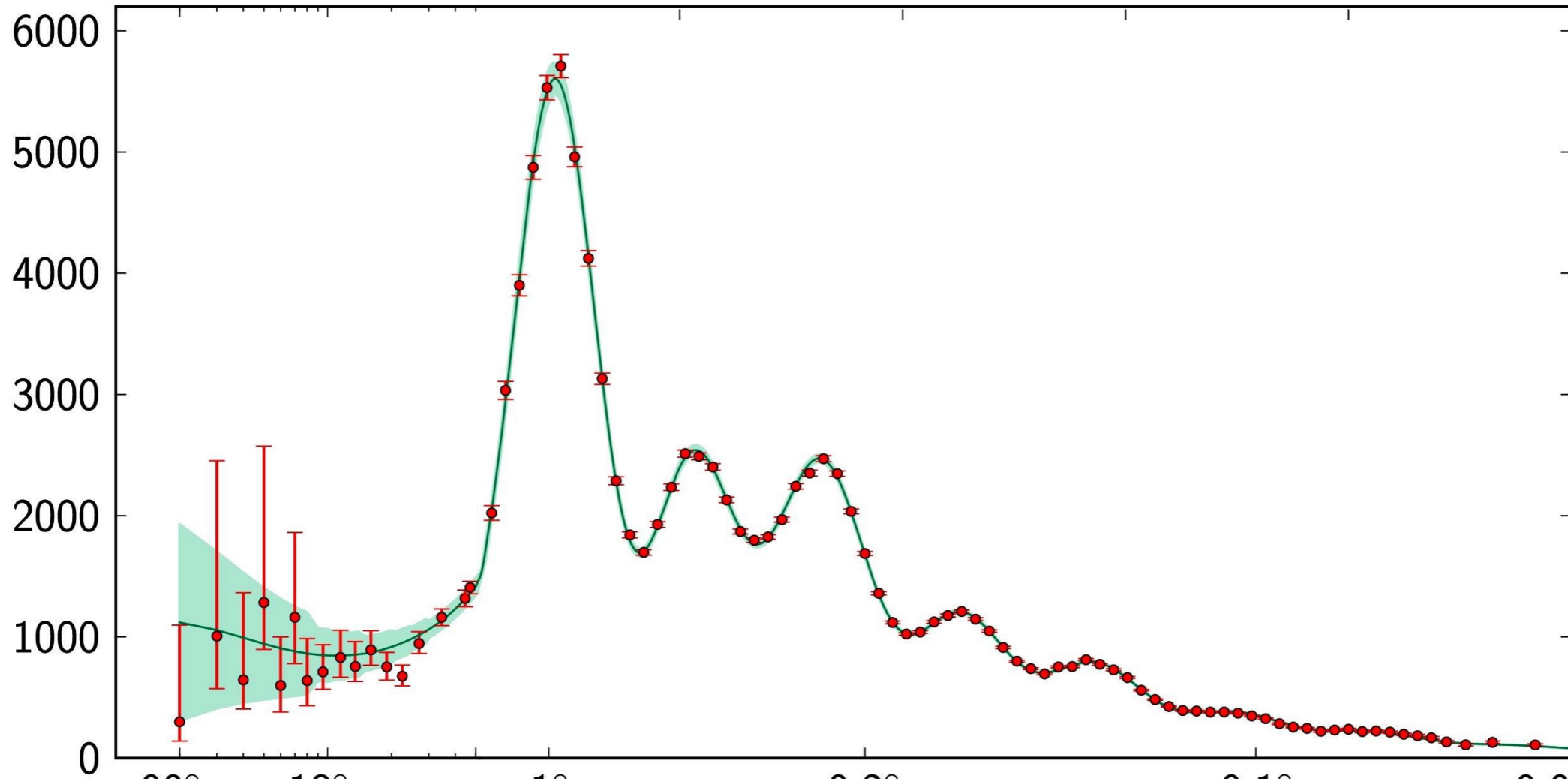
**Originally: Quantum Fluctuations**



Multipole moment,  $\ell$

2 10 50 500 1000 1500 2000 2500

Temperature fluctuations [ $\mu\text{K}^2$ ]

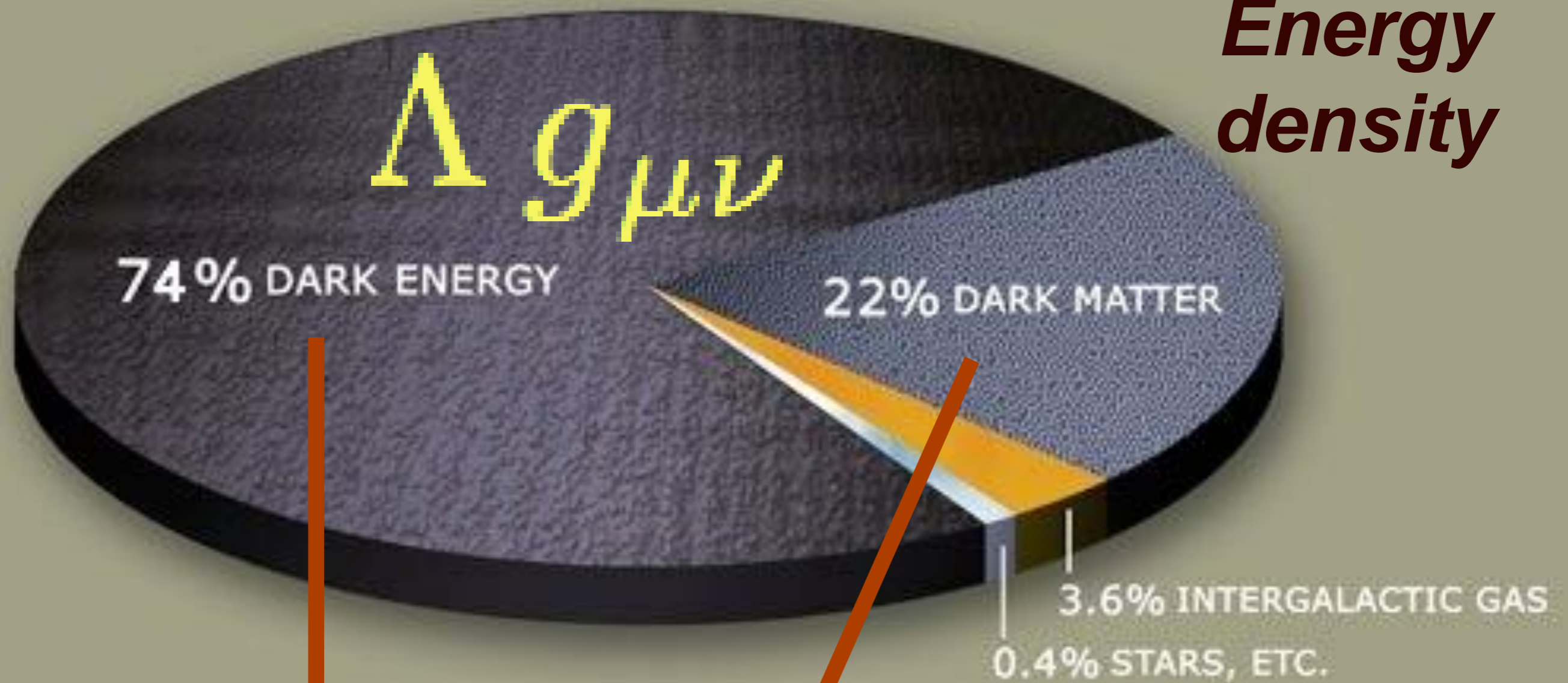


Angular scale





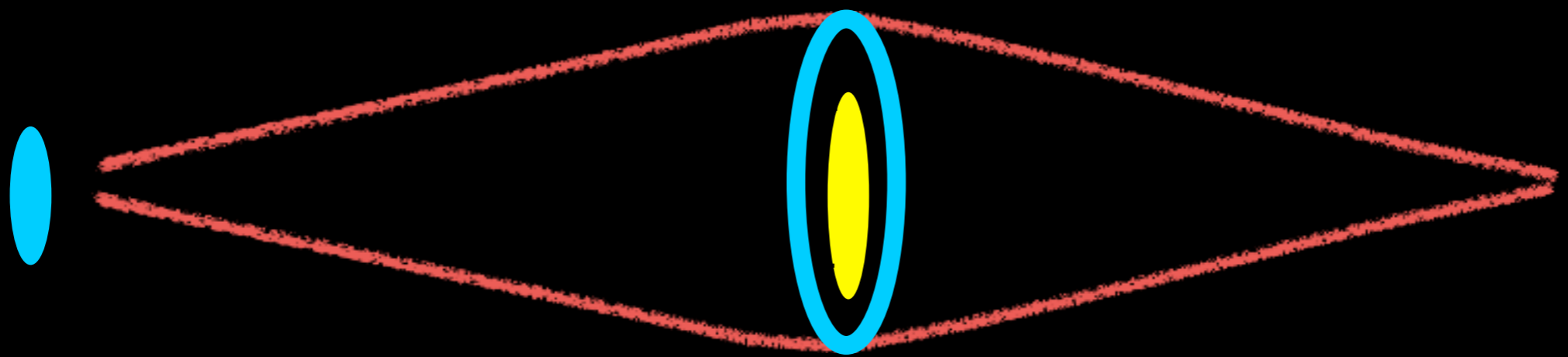
*Energy density*



not talk much TODAY

!!! ENERGY OF THE VACUUM !!!



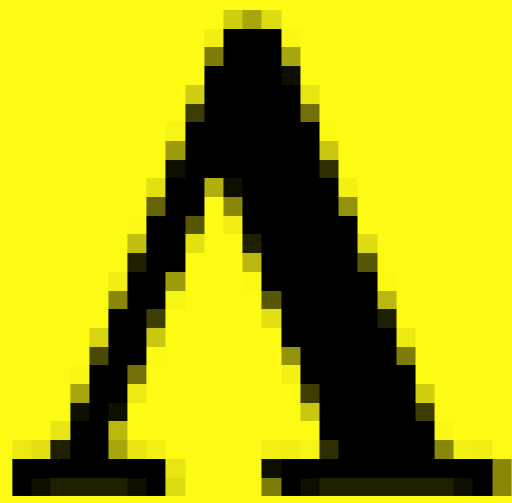




4/5







**“COSMOLOGICAL CONSTANT”**

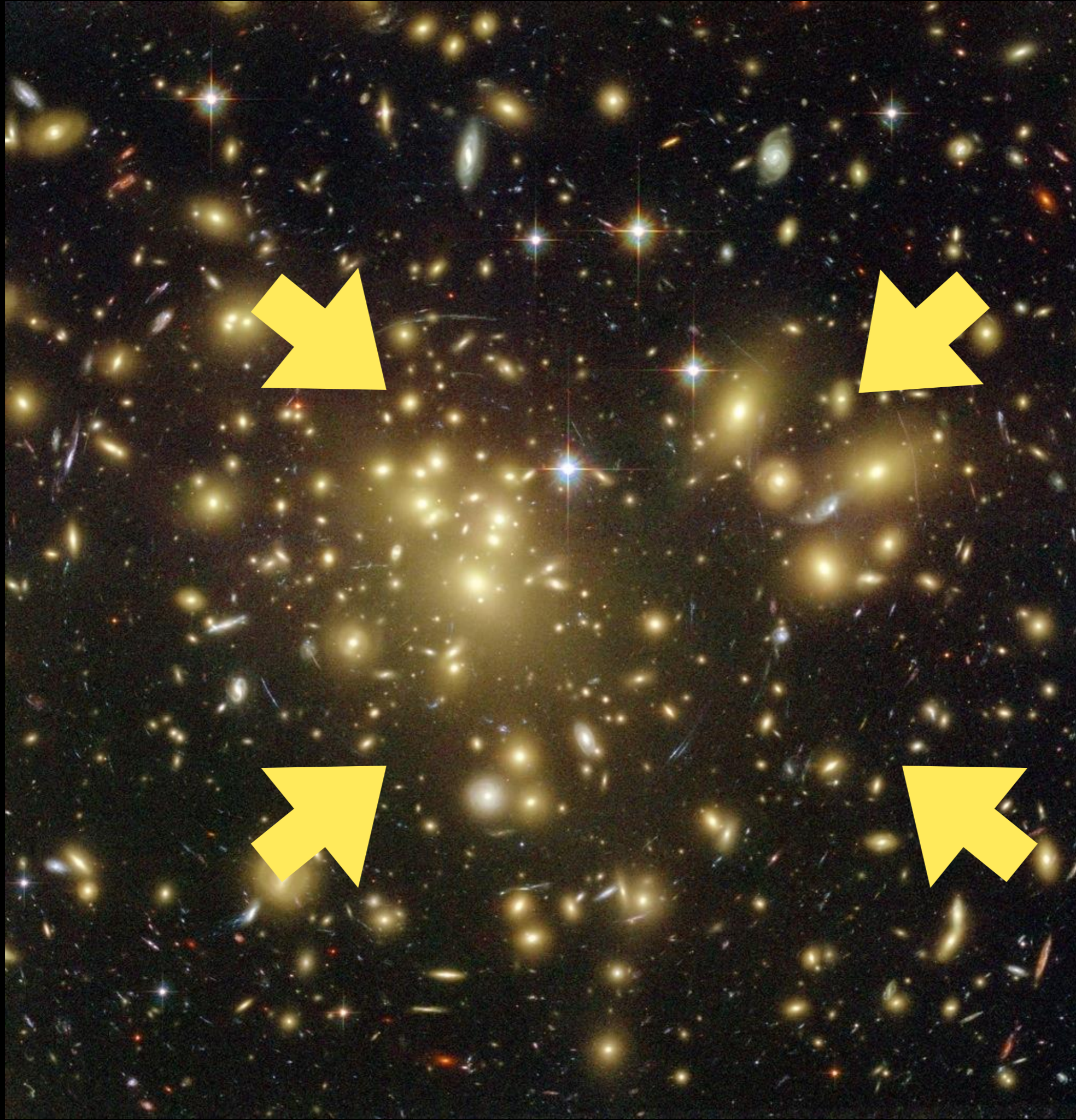
***A.E.: His biggest error***

***????????????????***

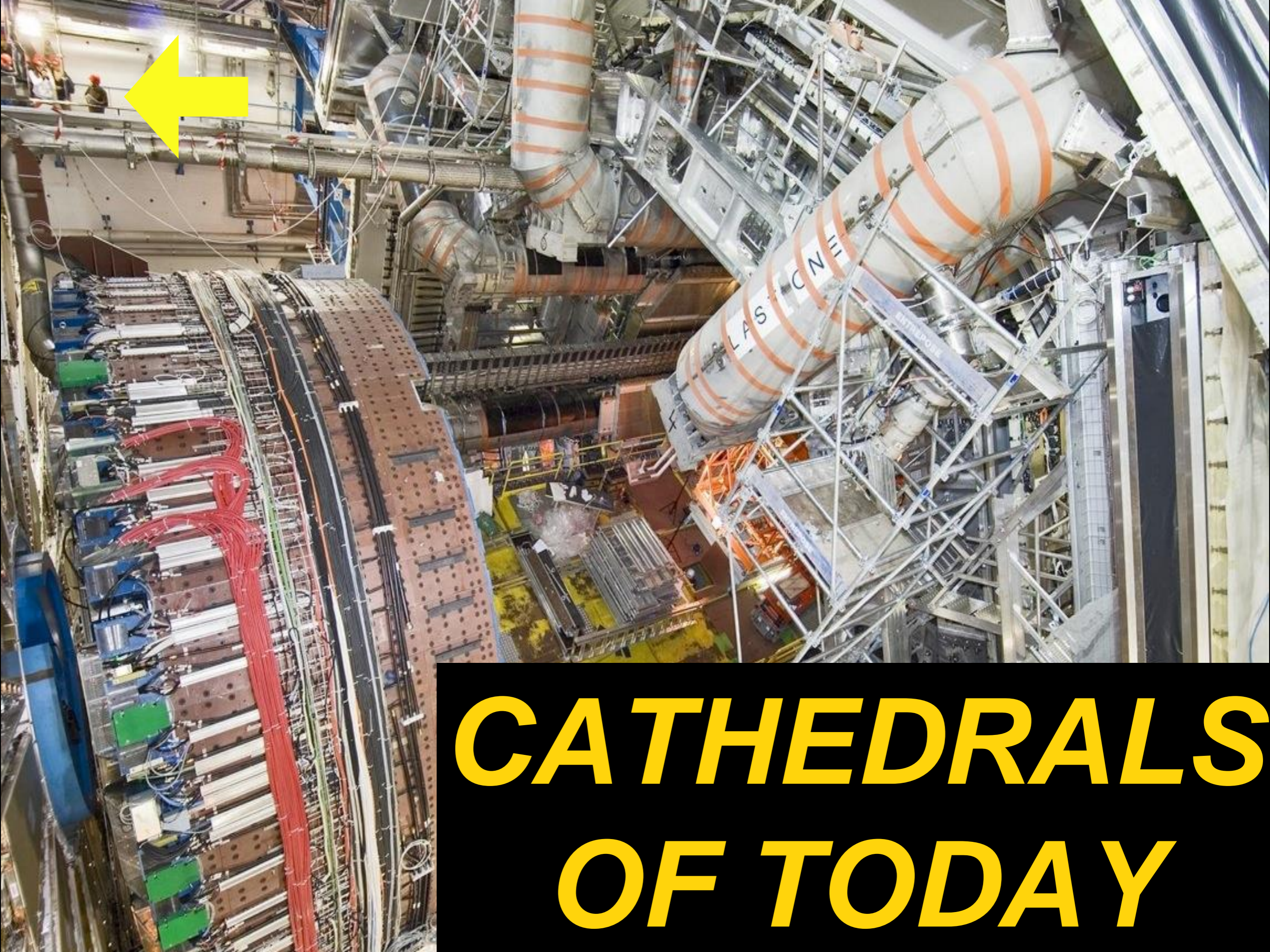
***Dark Energy density***

***of the VACUUM !!***









***CATHEDRALS  
OF TODAY***







A person wearing a traditional brown thobe and ghutra is performing a prostration on a sandy surface. The person is kneeling with their hands and forehead touching the sand, and their back is arched. The scene is brightly lit, casting shadows on the sand. The word "DIFFERENCE" is overlaid in large, bold, yellow capital letters at the bottom of the image.

**DIFFERENCE**



(Peu à peu sortant de la brume)

16

*sempre pp*

*p marqué*

*pp*

18

*p marqué*

*pp*

*p*

*marqué*

Claude Debussy, *La Cathédrale engloutie*  
mes. 16-19





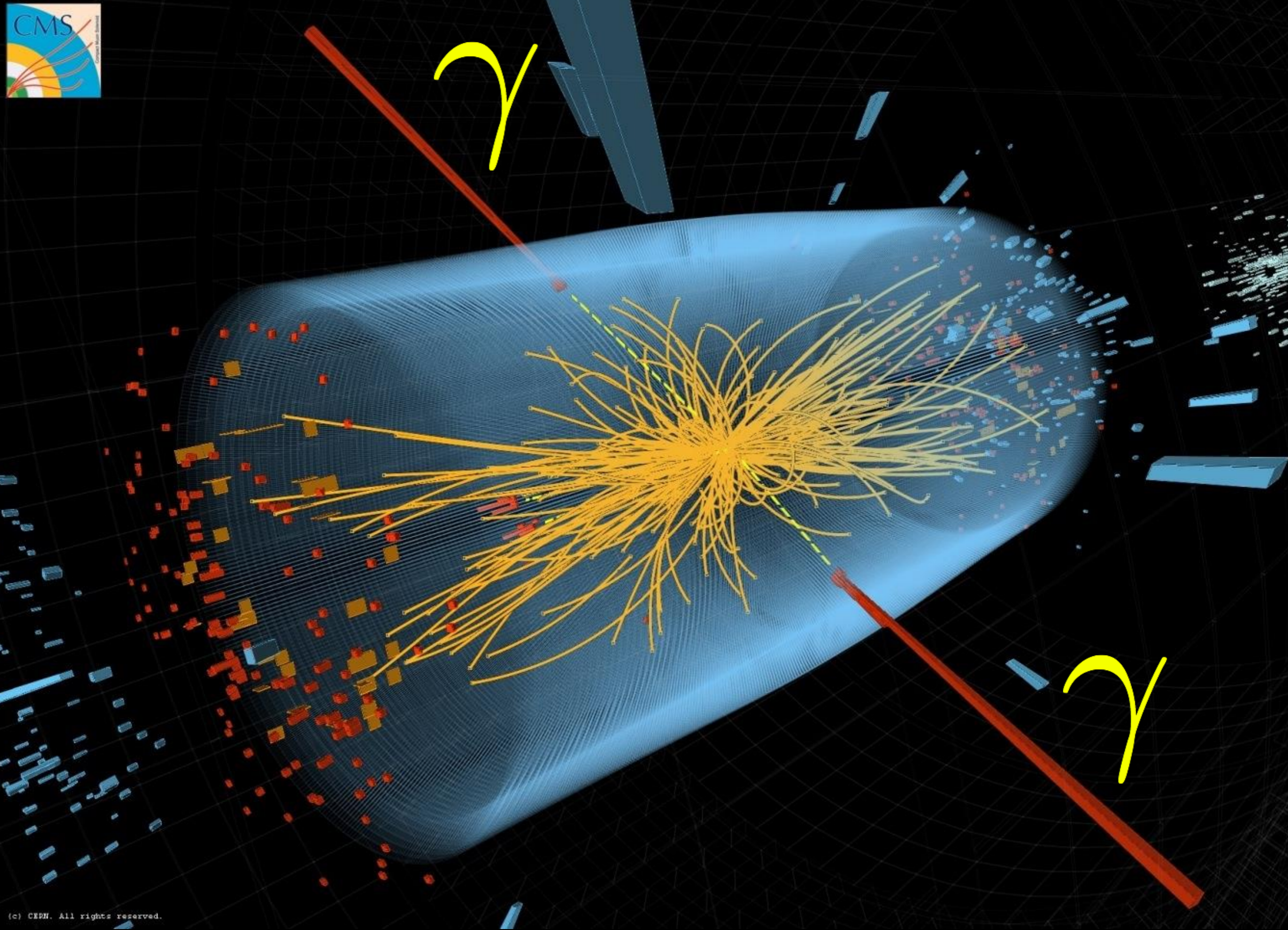




**C  
S  
E  
R  
G  
I  
O  
L  
I  
N**

**LHC**



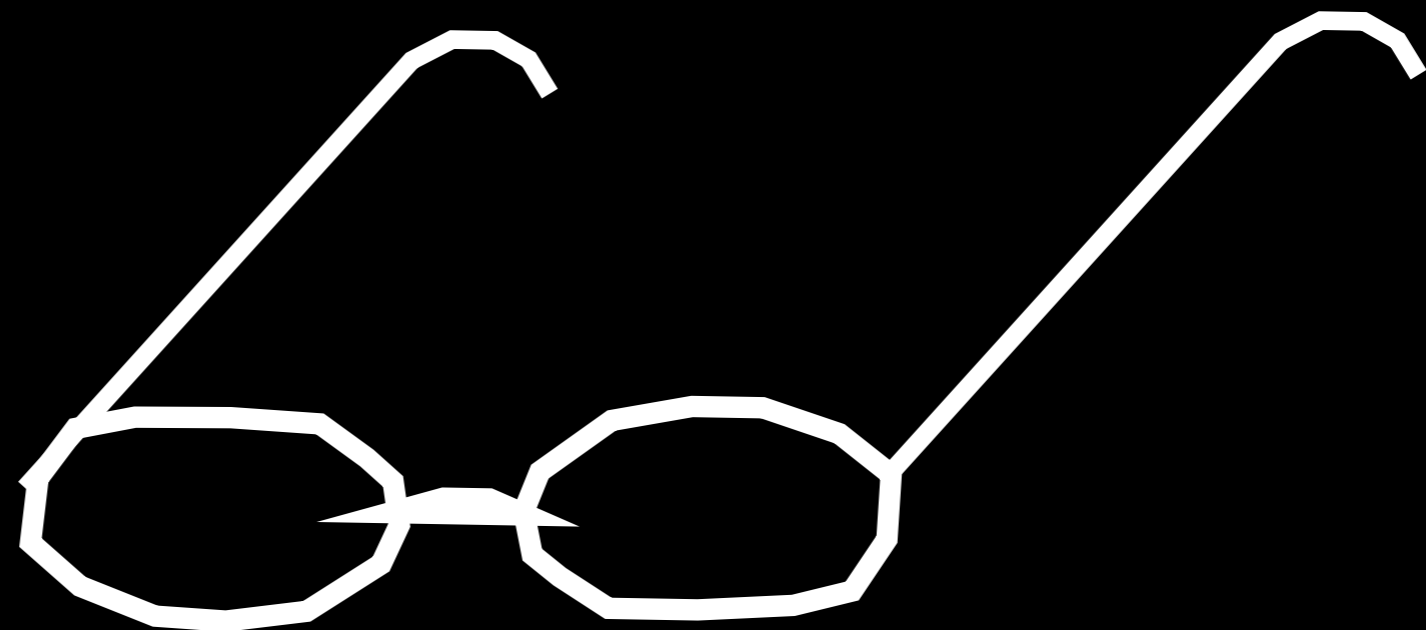








There remains ...  
There remains  
the HIGGS field,  
the Earth's  
Universal Uniform  
Gravitational Field





The **VACUUM** is  
a **SUBSTANCE**

$$\varphi_0 \neq 0$$



If the vacuum is a  
substance

One can shake it

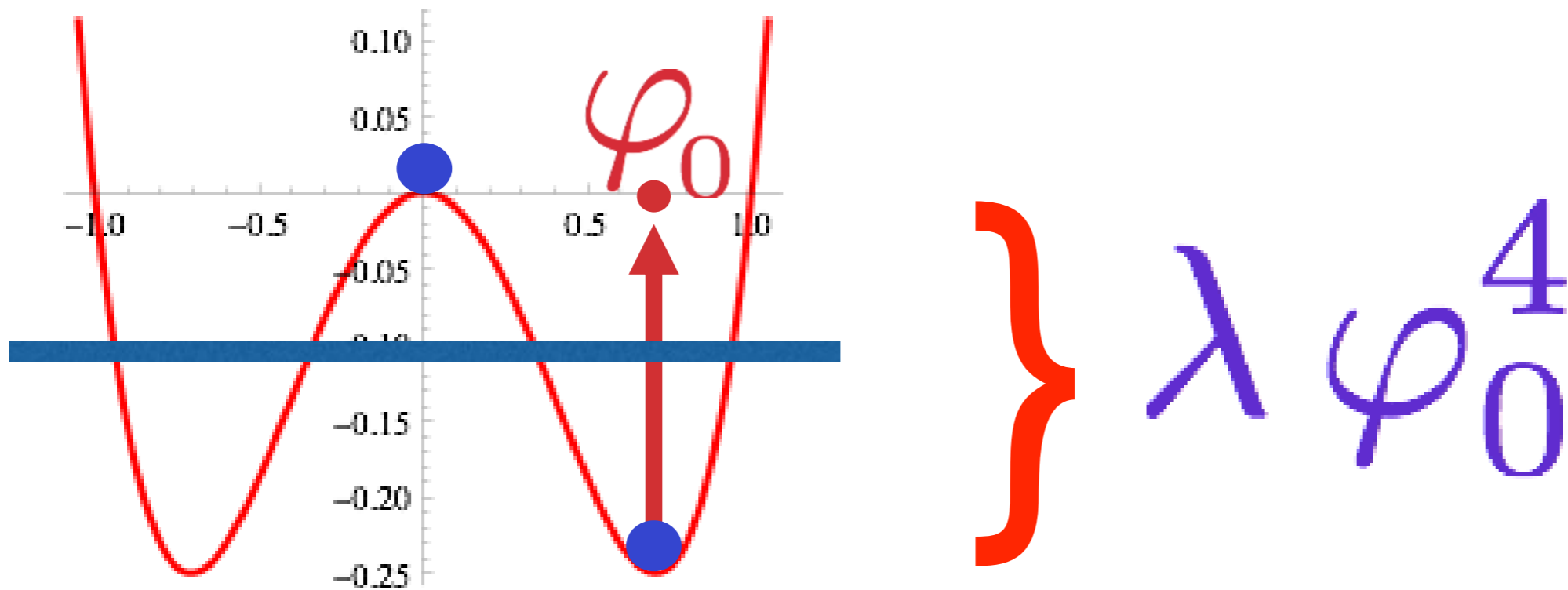
Its vibrations are elementary particles

\*The

Higgs\*  
TO KEGUOV OV

LHC = MSV





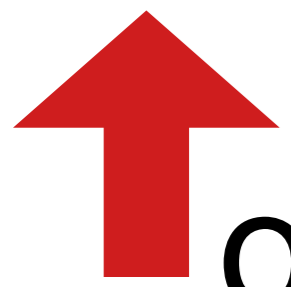
**Higgs  $\Rightarrow$  Vacuum Energy Density ( $\Lambda$ )**

$$\Lambda(\text{Cosmologi}) \simeq$$

$$10^{-56} \Lambda(\text{Mec. di Higgs})$$



# The “STANDARD MODELS”



of the macro- and micro-cosmos





***WE DO NOT UNDERSTAND***

**The vacuum (well enough)**

***1 Reason for a Higgs factory***

**What Dark Matter is**

***1 Reason for yet H(er)EP & etc....***

***\* GRAVITY AS A QUANTUM THEORY***

***\* THE RELATION BETWEEN GRAVITY***

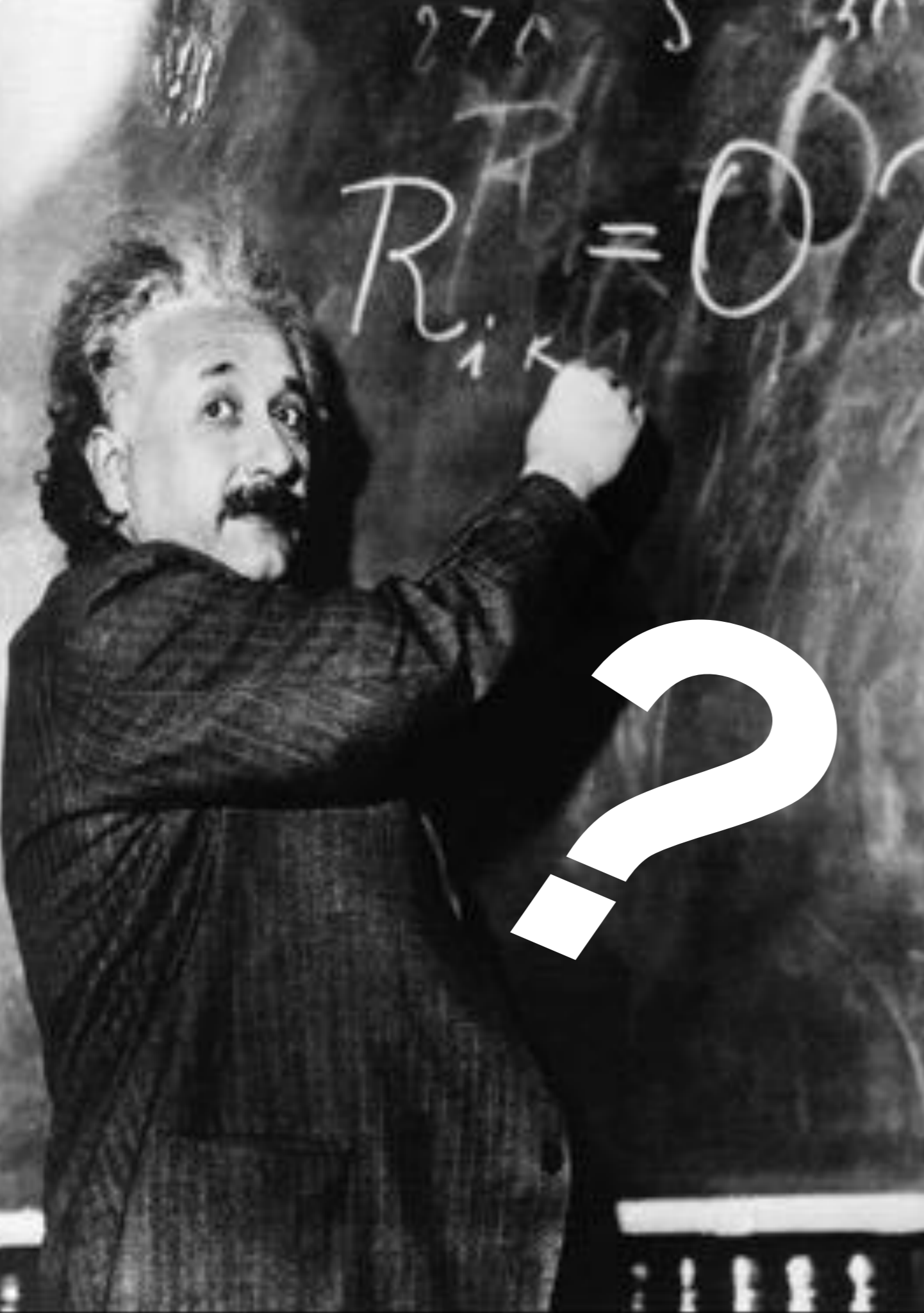
***\* AND THE OTHER BASIC FORCES***

***2 Reasons for > \$ of H.E. Theorists***

**Why Nature is describable with simple laws**

***An interesting (meta-)question to ask***



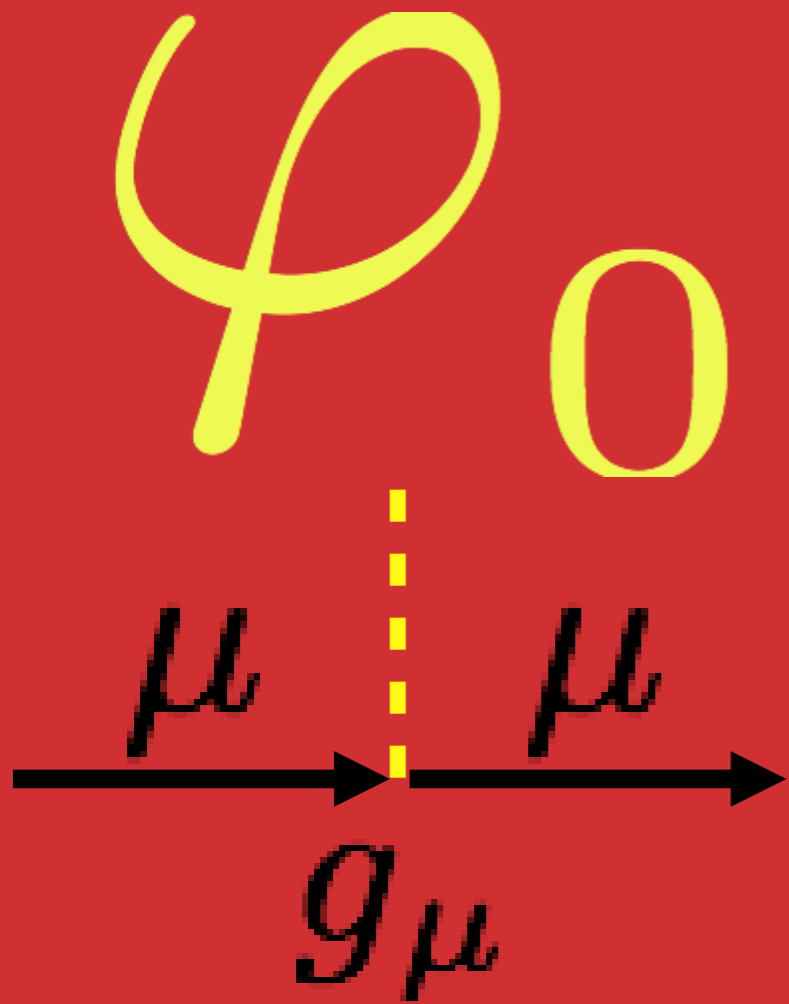






**STOP**





***m*** ?

$$L_m[\mu] = \overbrace{g_\mu \varphi_0} \bar{\Psi}_\mu \Psi_\mu$$



