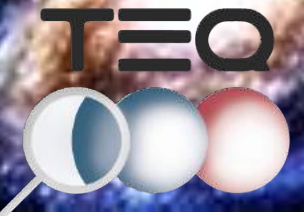


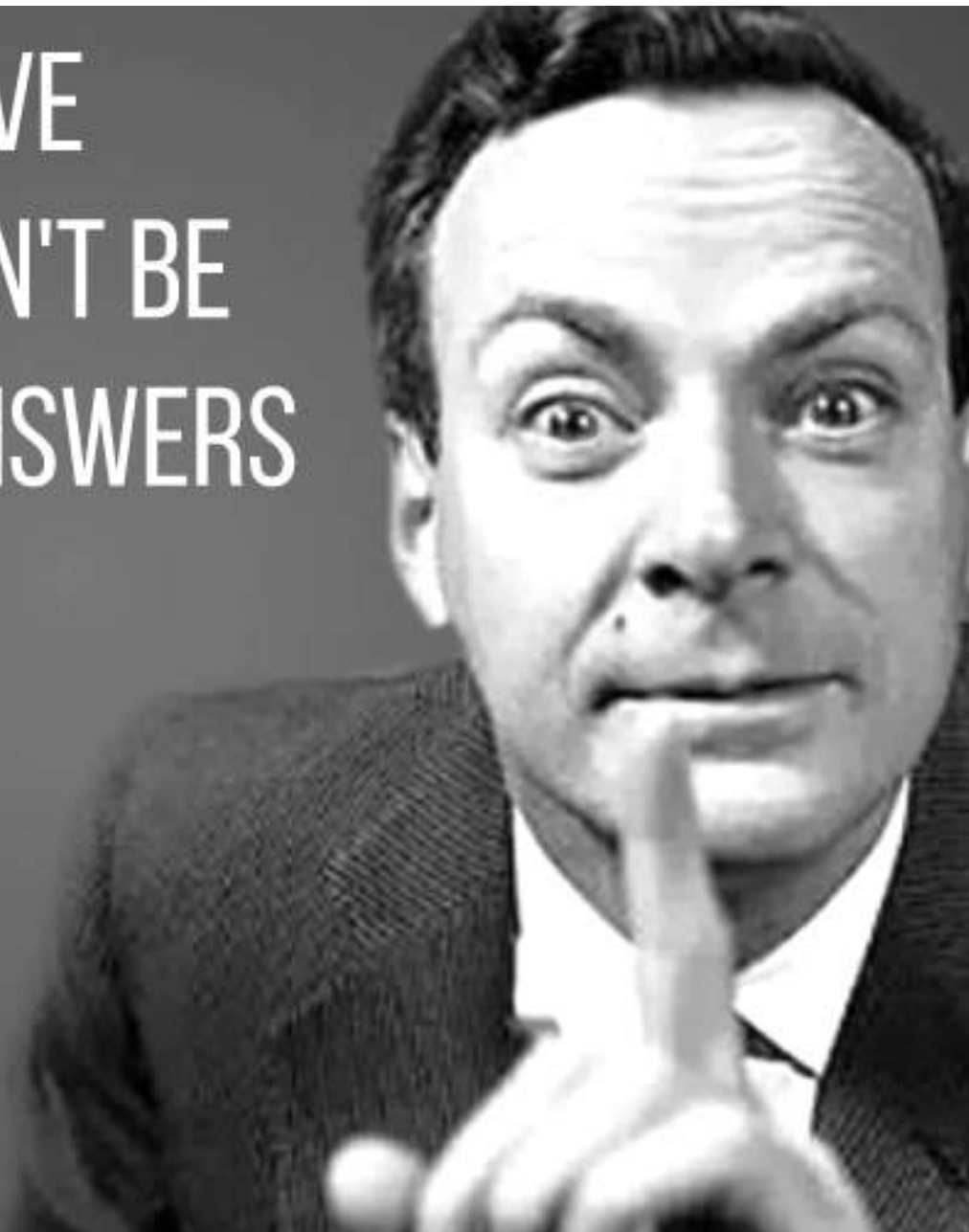
# Q: Quarks, Quantum, Blaq Holes and open questions INSPIRE 2018 Catalina Curceanu, LNF-INFN 16th february 2018



I WOULD RATHER HAVE  
QUESTIONS THAT CAN'T BE  
ANSWERED THAN ANSWERS  
WHICH CAN'T BE  
QUESTIONED.

- RICHARD FEYNMAN

GODLESSMOM.COM



**You Are Here!**



# Modern Physics

Two “**scientific revolutions**” in the 20th century:

- **Theory of Relativity**
- **Quantum Mechanics**

# Relativity

*Imagine travelling through space on a beam of light at the speed of light.*



*Albert Einstein, theory of relativity, gravity, velocity, energy, mass, speed, time,  $E=mc^2$  Albert Ein*

*Bobonart*

*Einstein – Aarau public school*



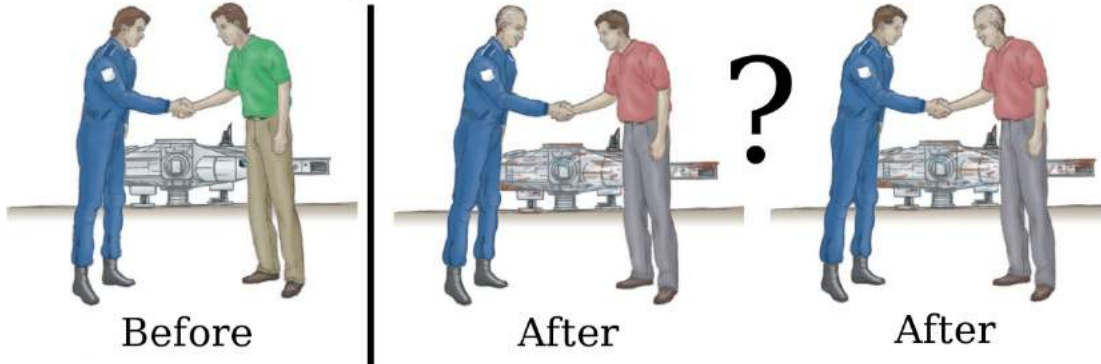


$$x' = \frac{(x - vt)}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$y' = y$$

$$z' = z$$

Twin paradox

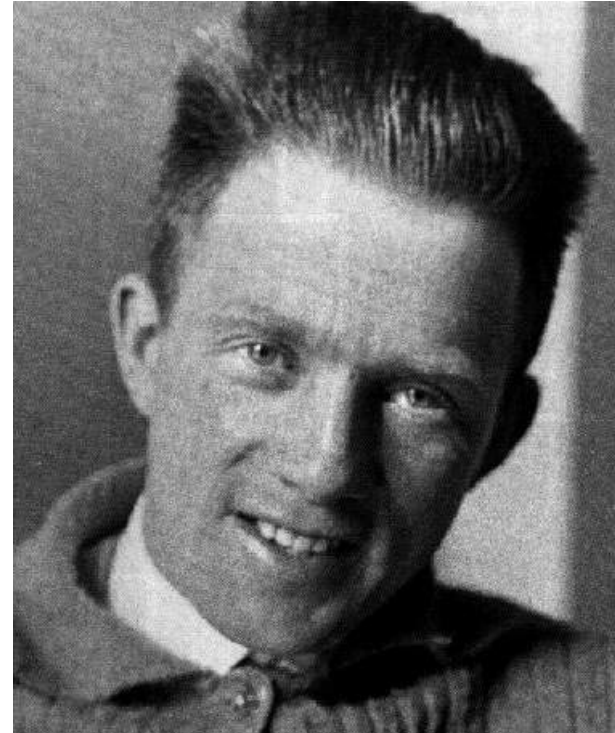


$$t' = \frac{t - \frac{xv}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}}$$

# Quantum Mechanics

For very small objects

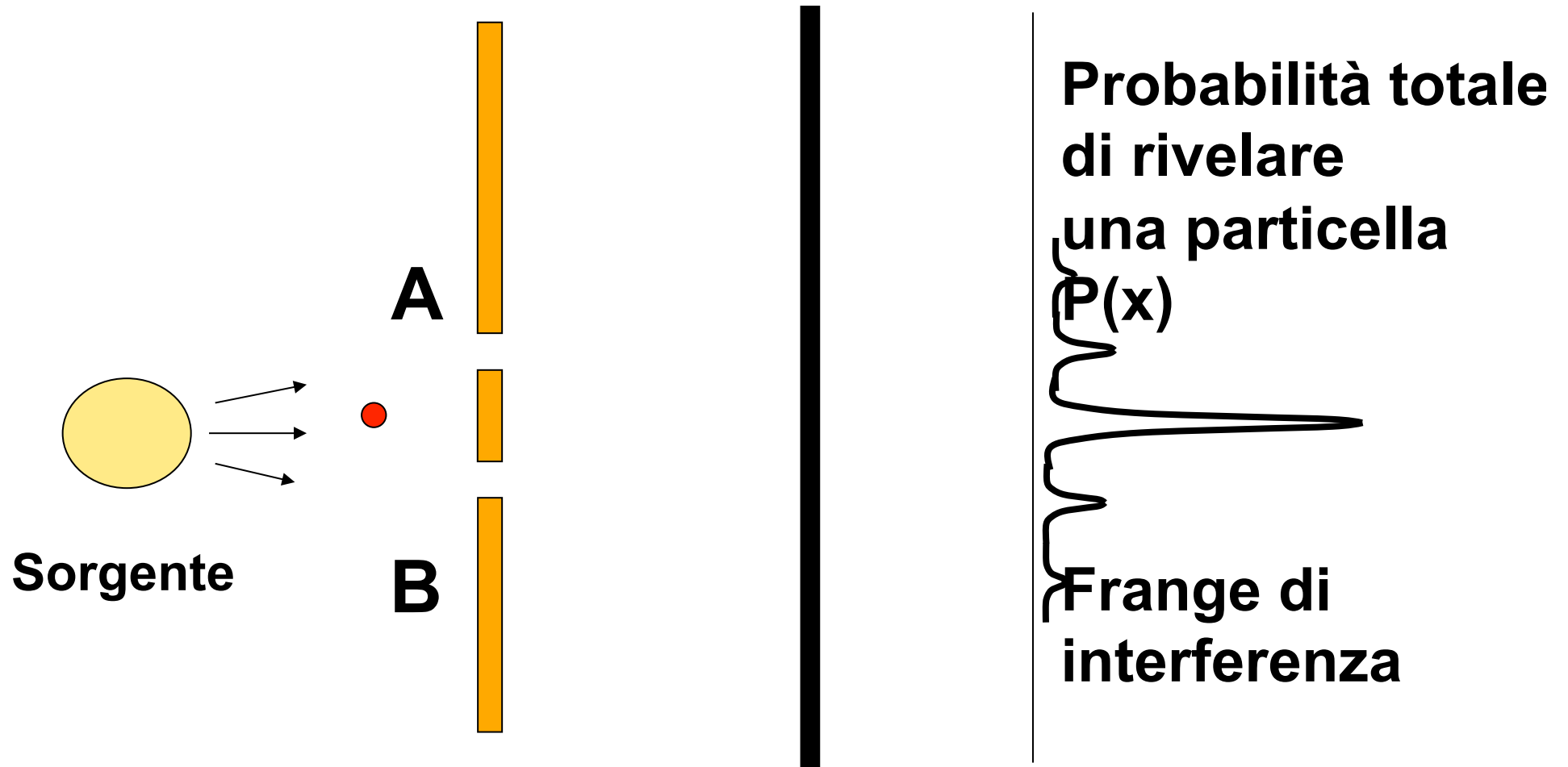
(as particles, atoms,  
molecules...)



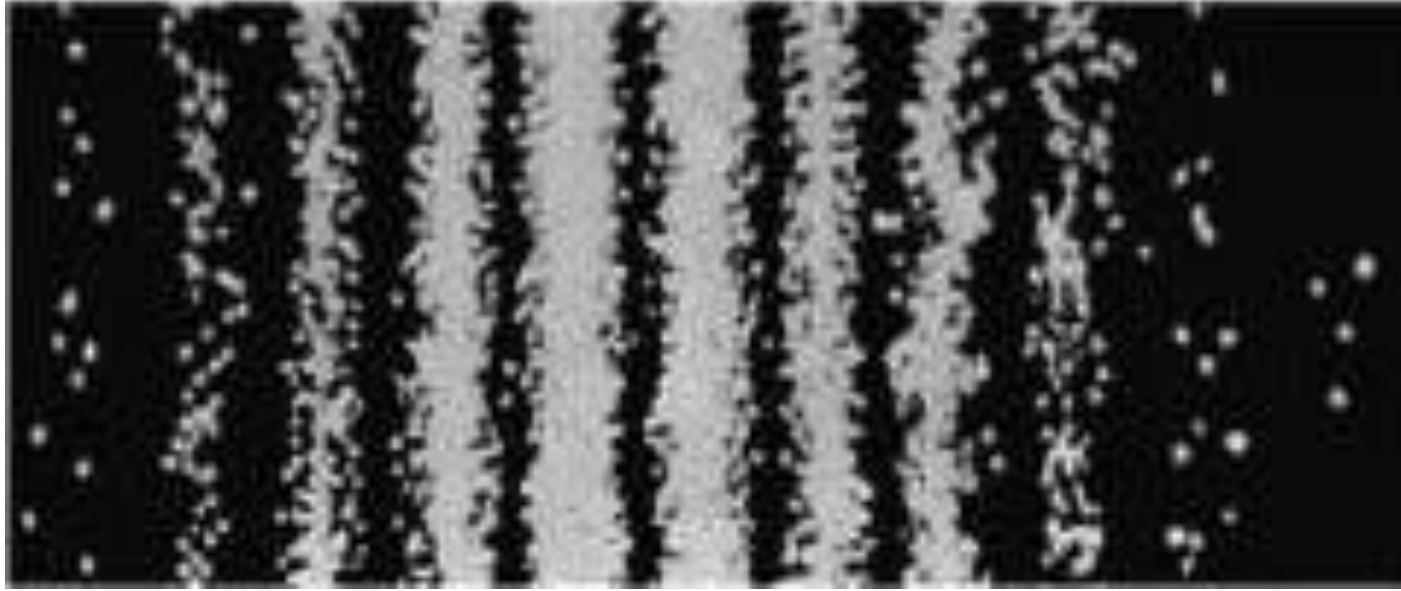
Heisenberg in 1925, 24 years old

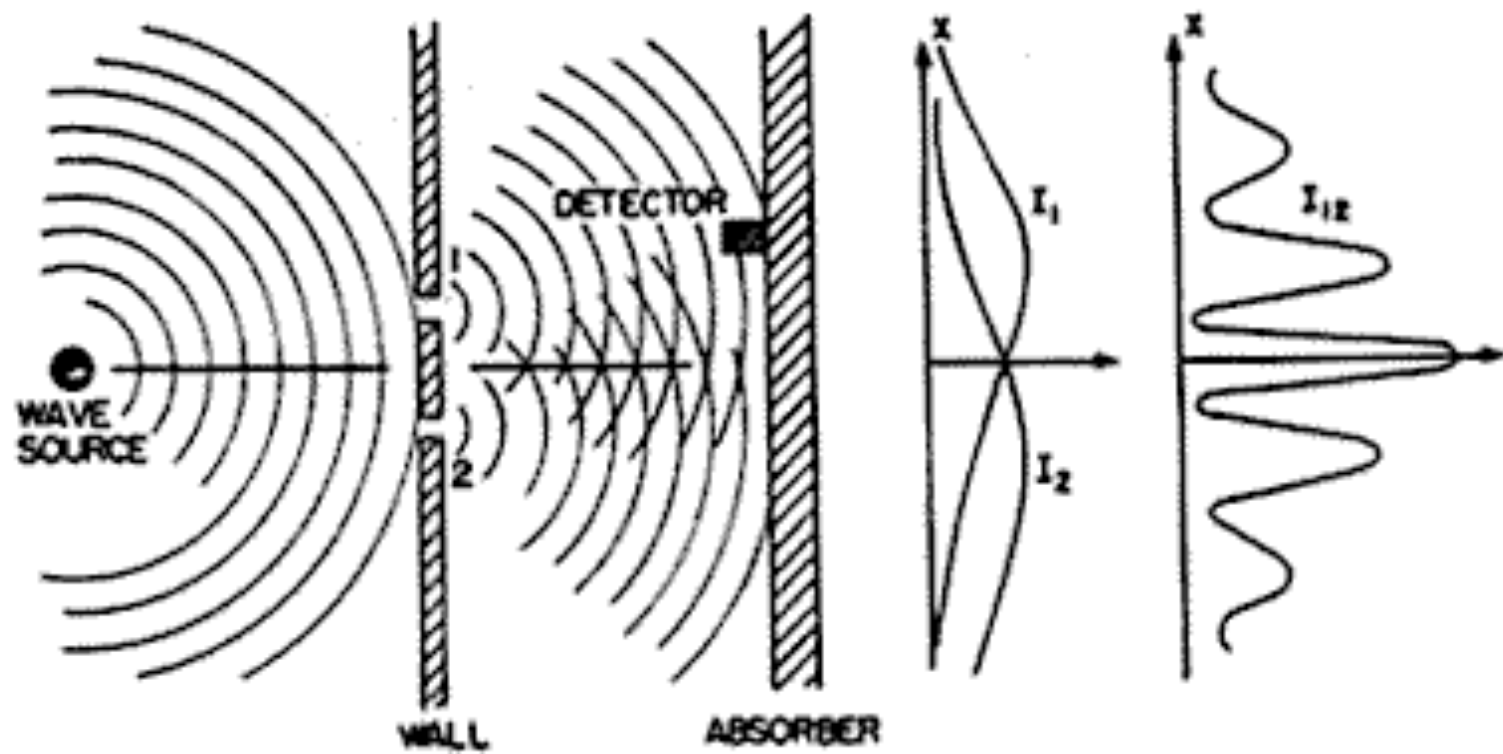


# Quantum interference



**The particle passes from BOTH doors!!**







Waves and particles

# Schrödinger cat – a paradox?







# Underground Gran Sasso laboratory

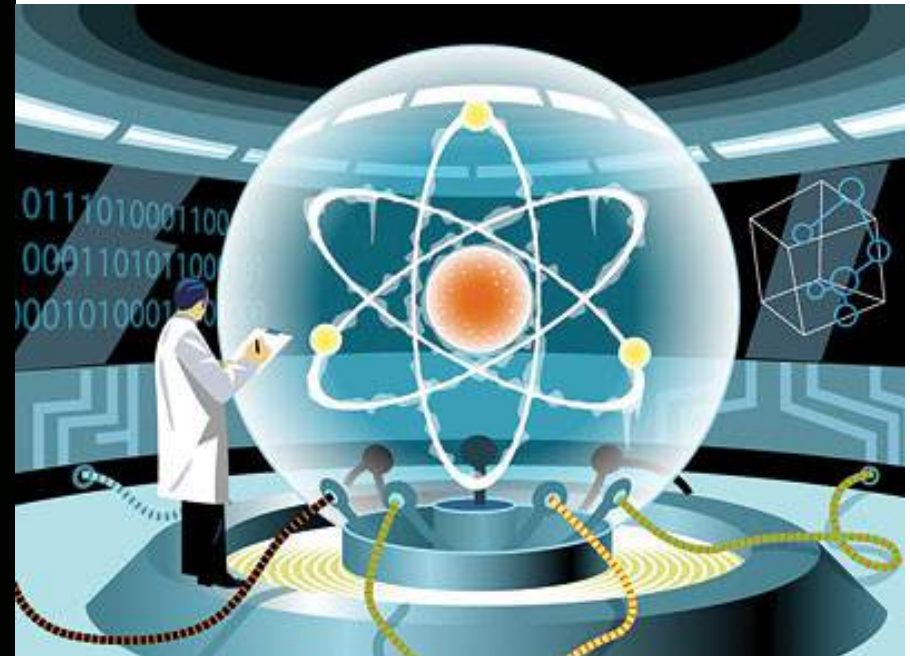


John  
Templeton  
Foundation

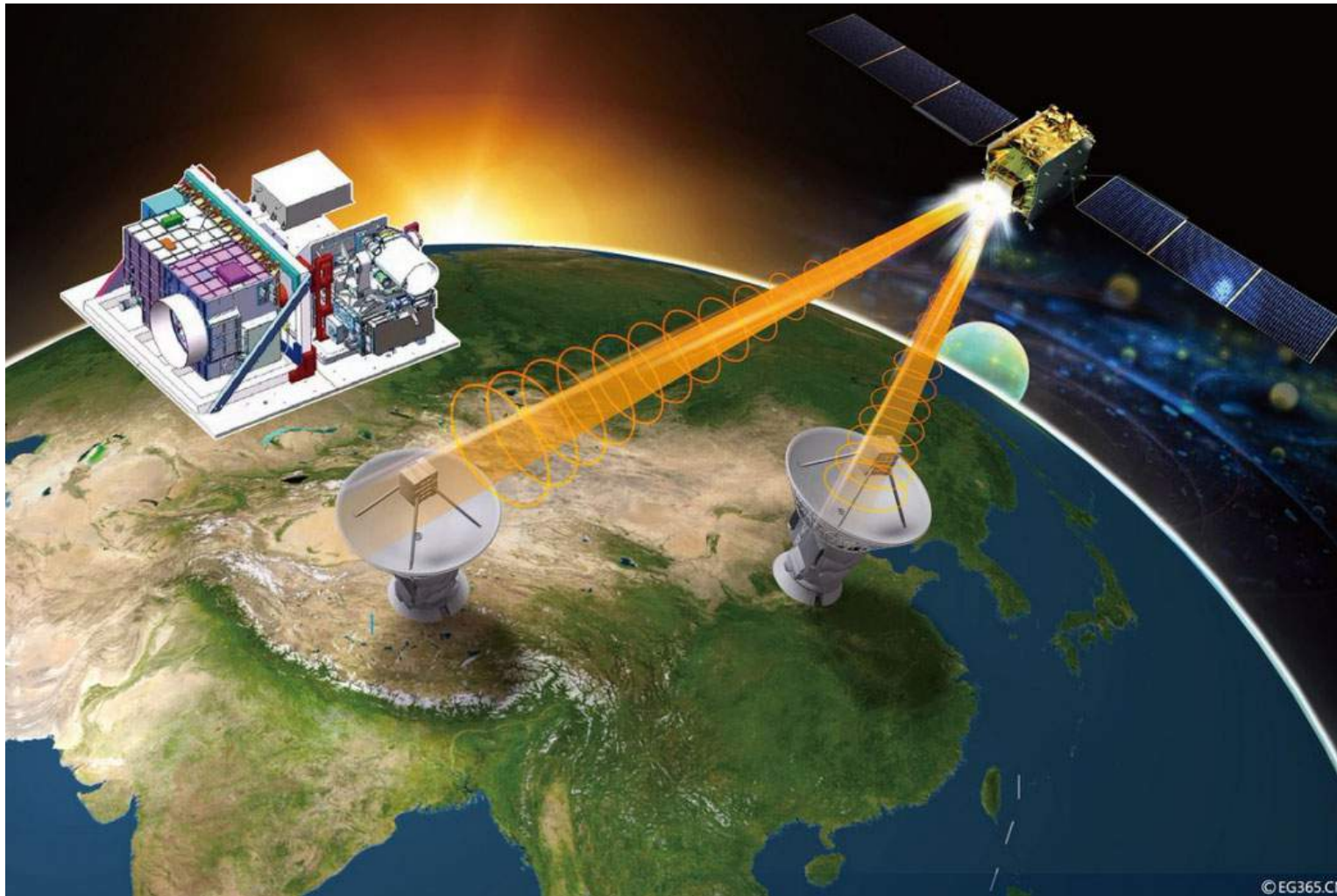




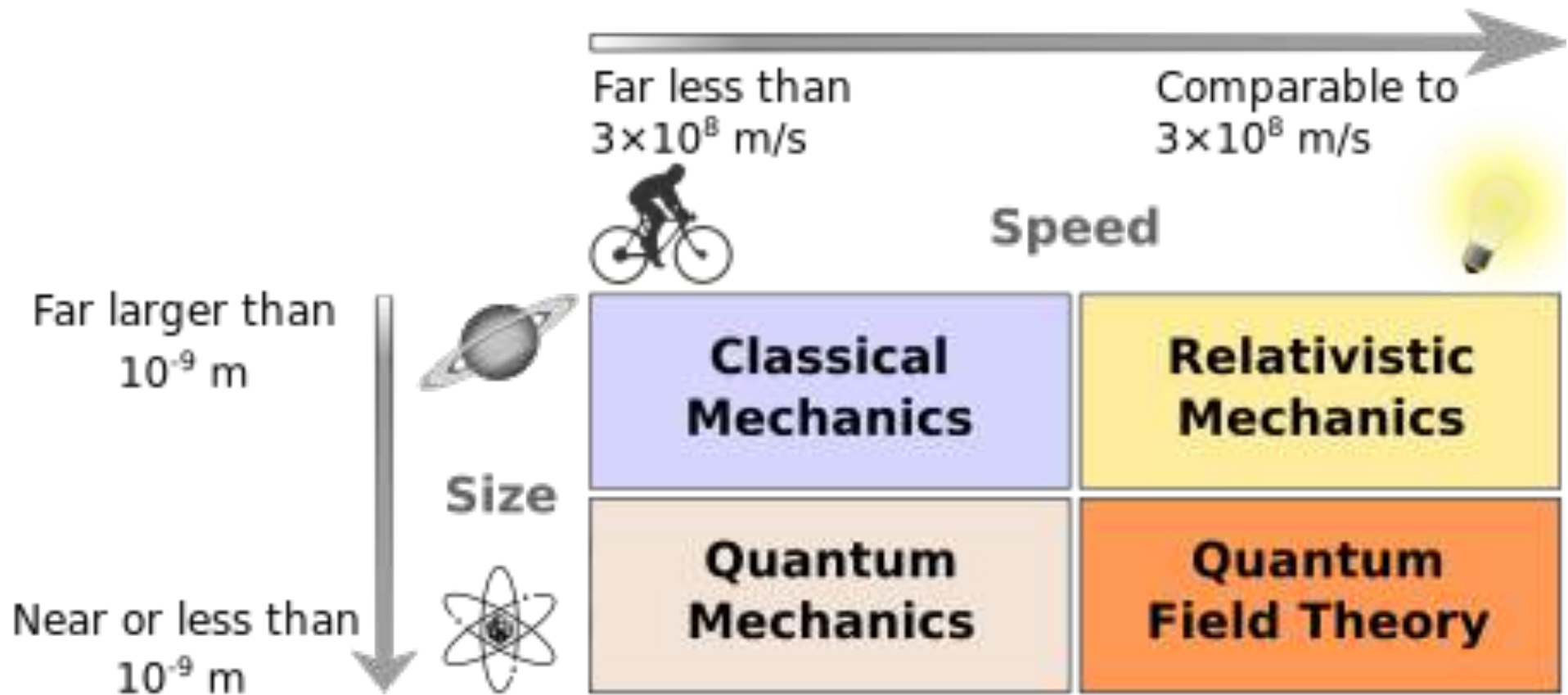
# Quantum Technologies



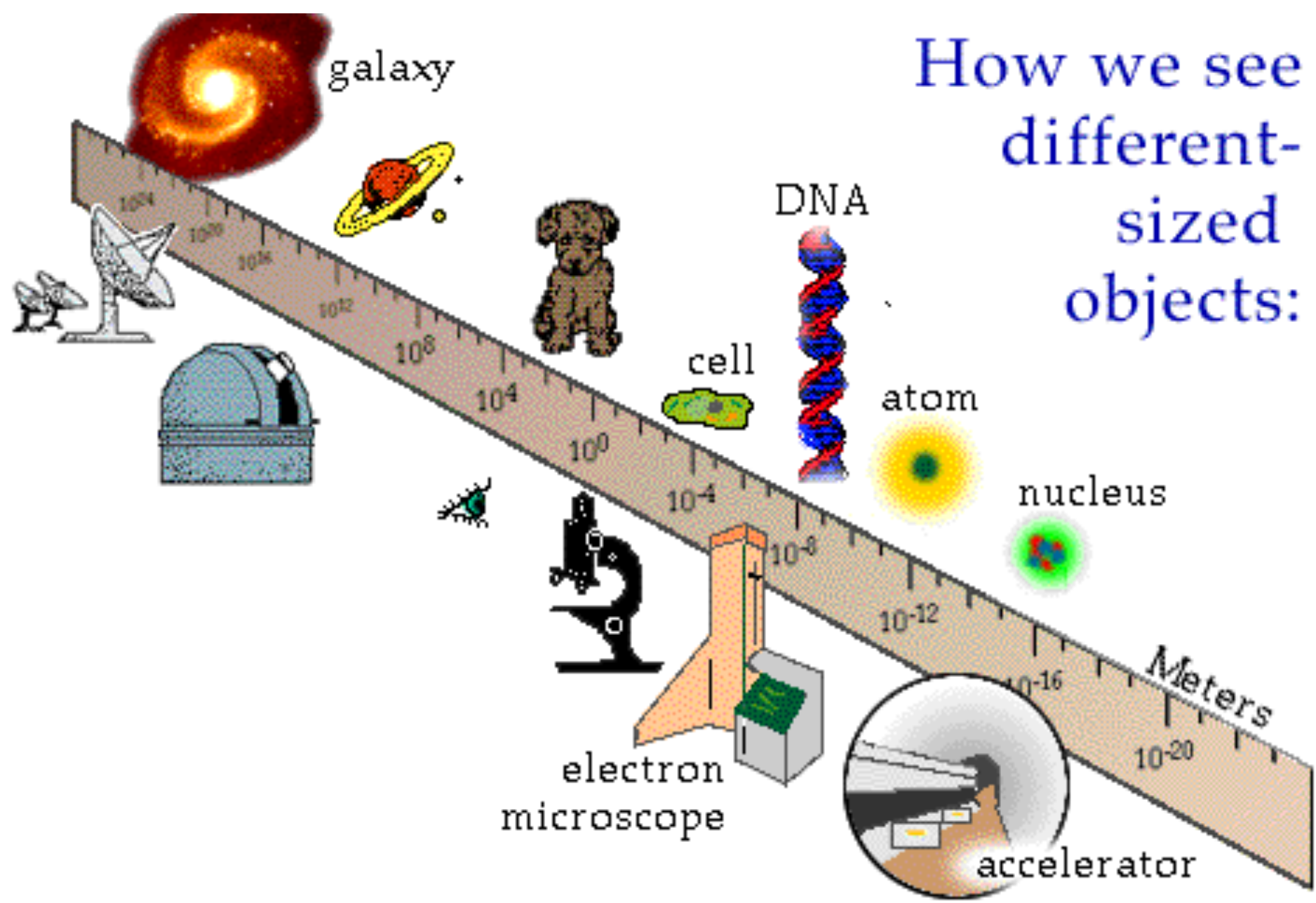
# Quantum Technologies in Space COST Action CA15220 e TEQ



# Modern physics

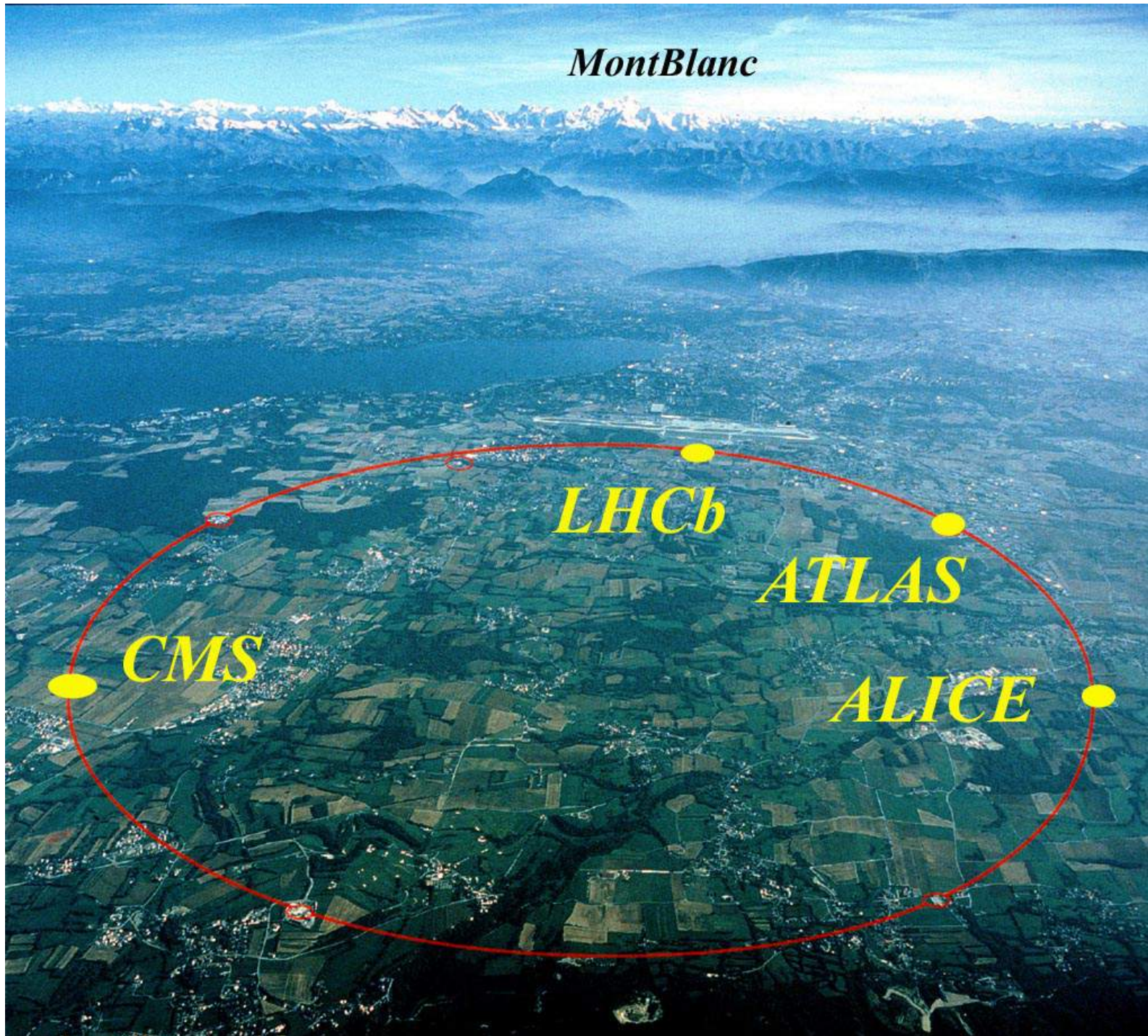


# How we see different-sized objects:





*MontBlanc*

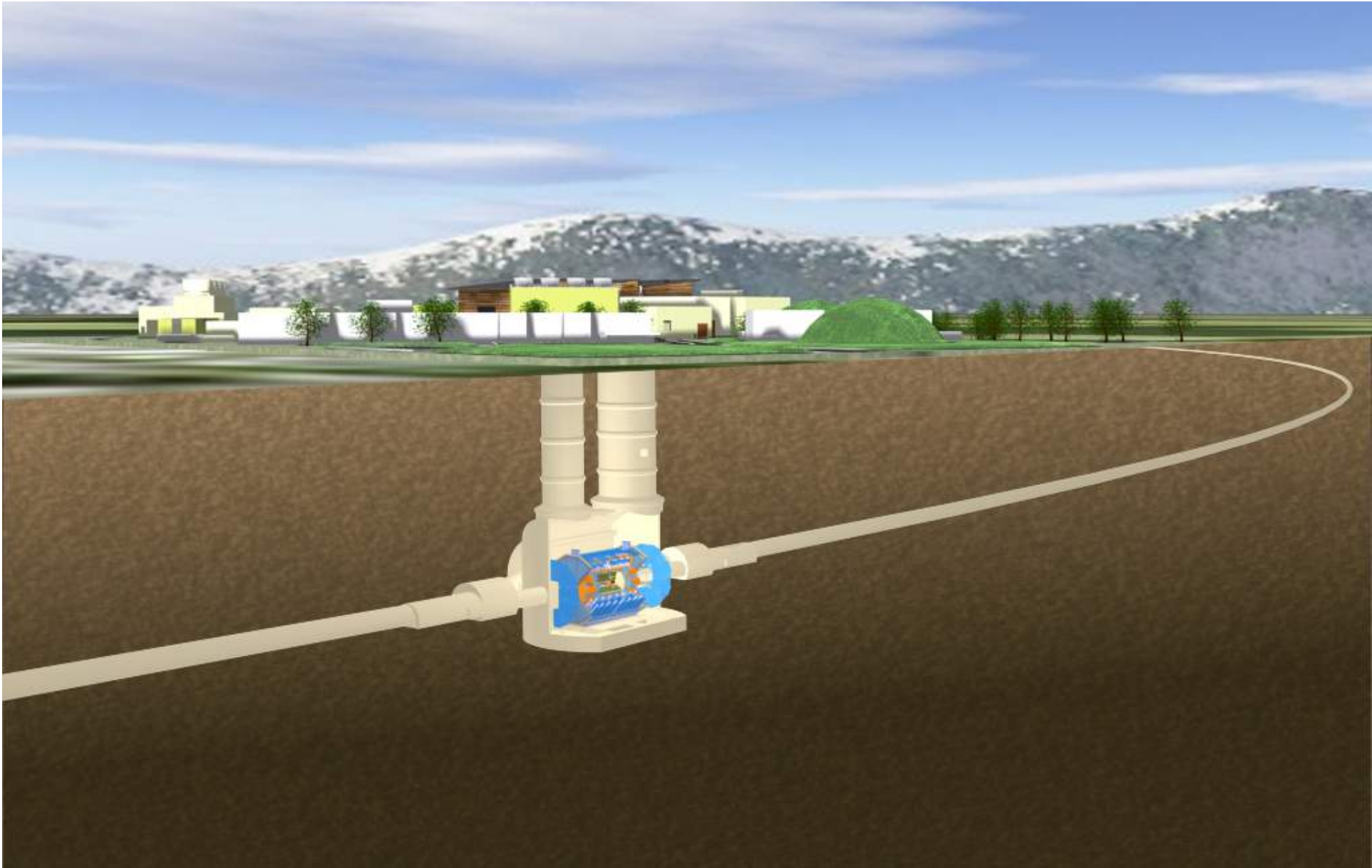


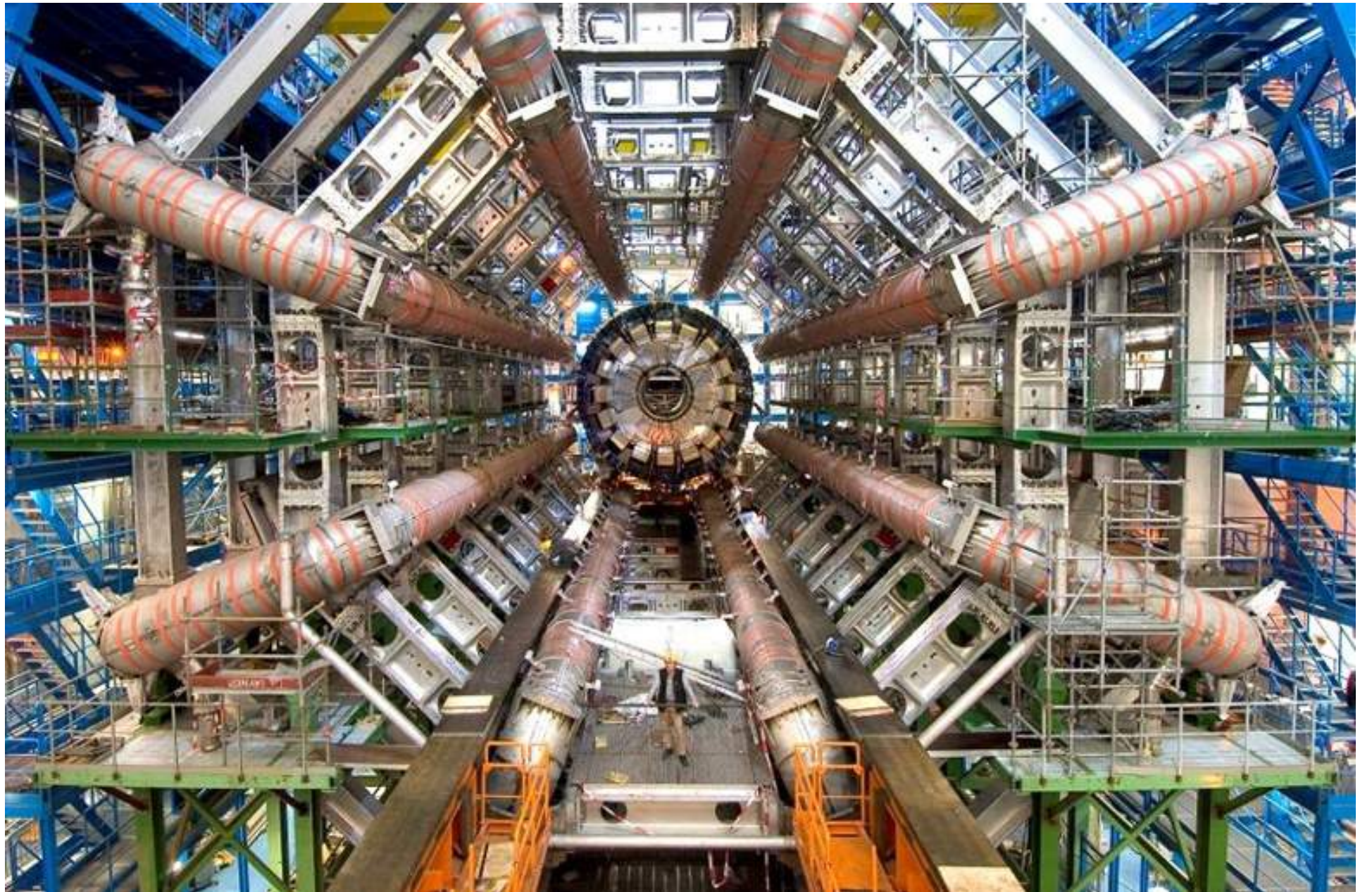
*CMS*

*LHCb*

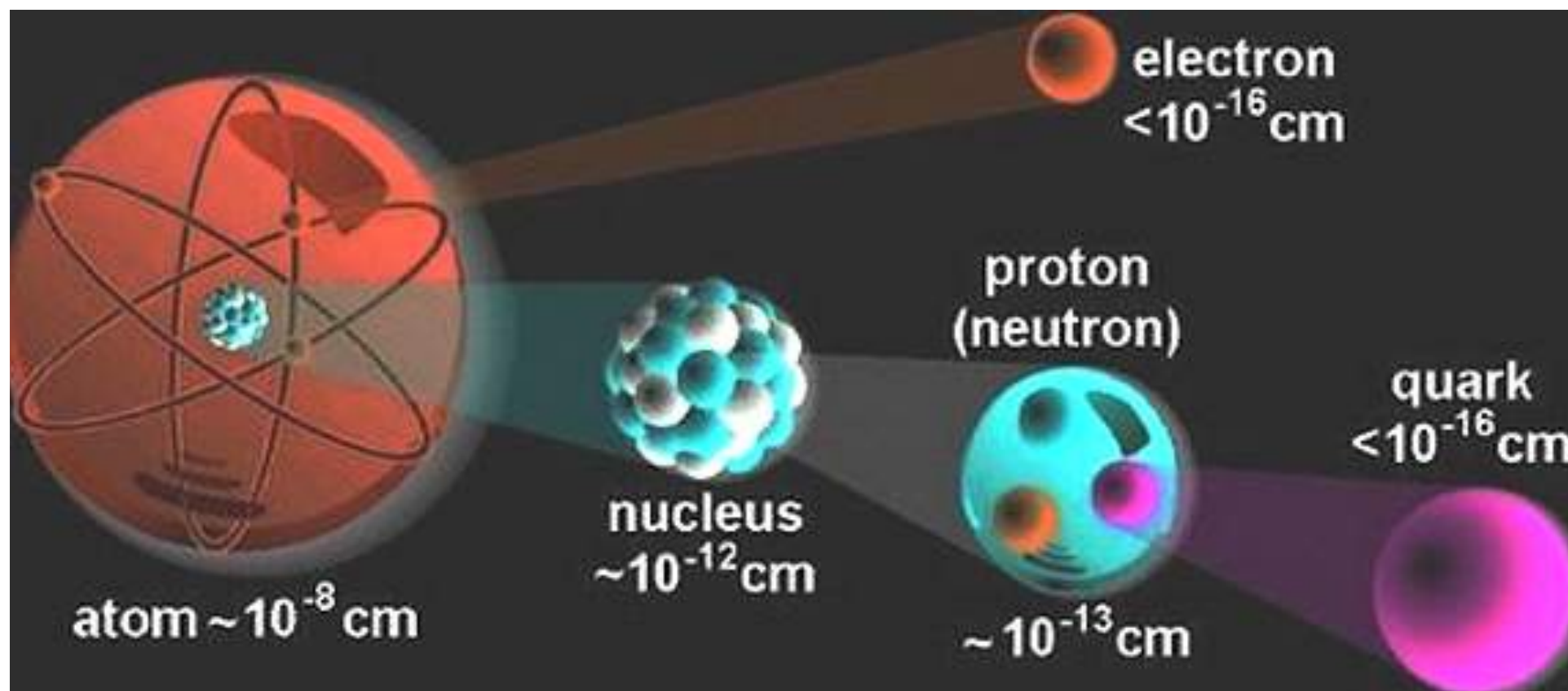
*ATLAS*

*ALICE*

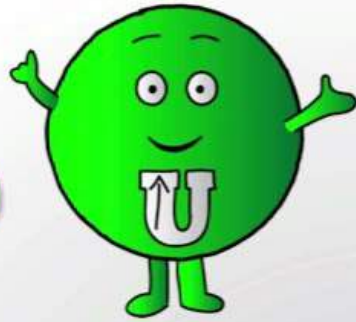




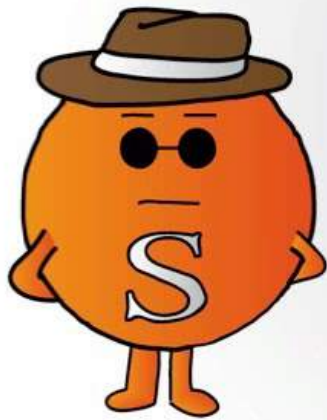




Up



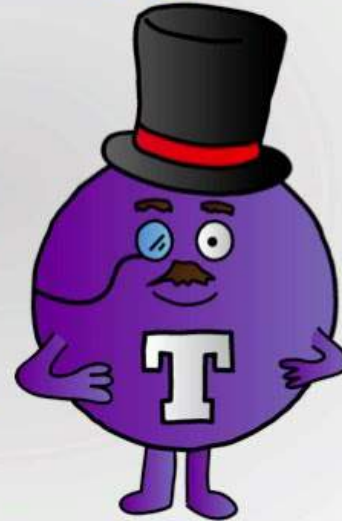
Down



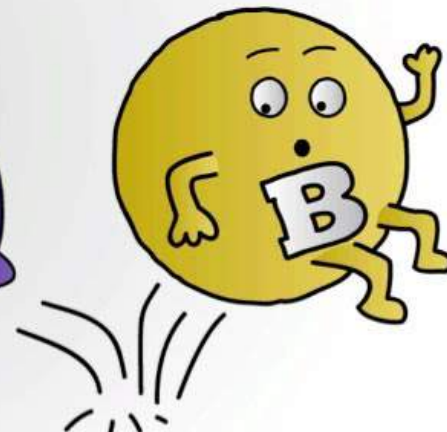
Strange



Charm

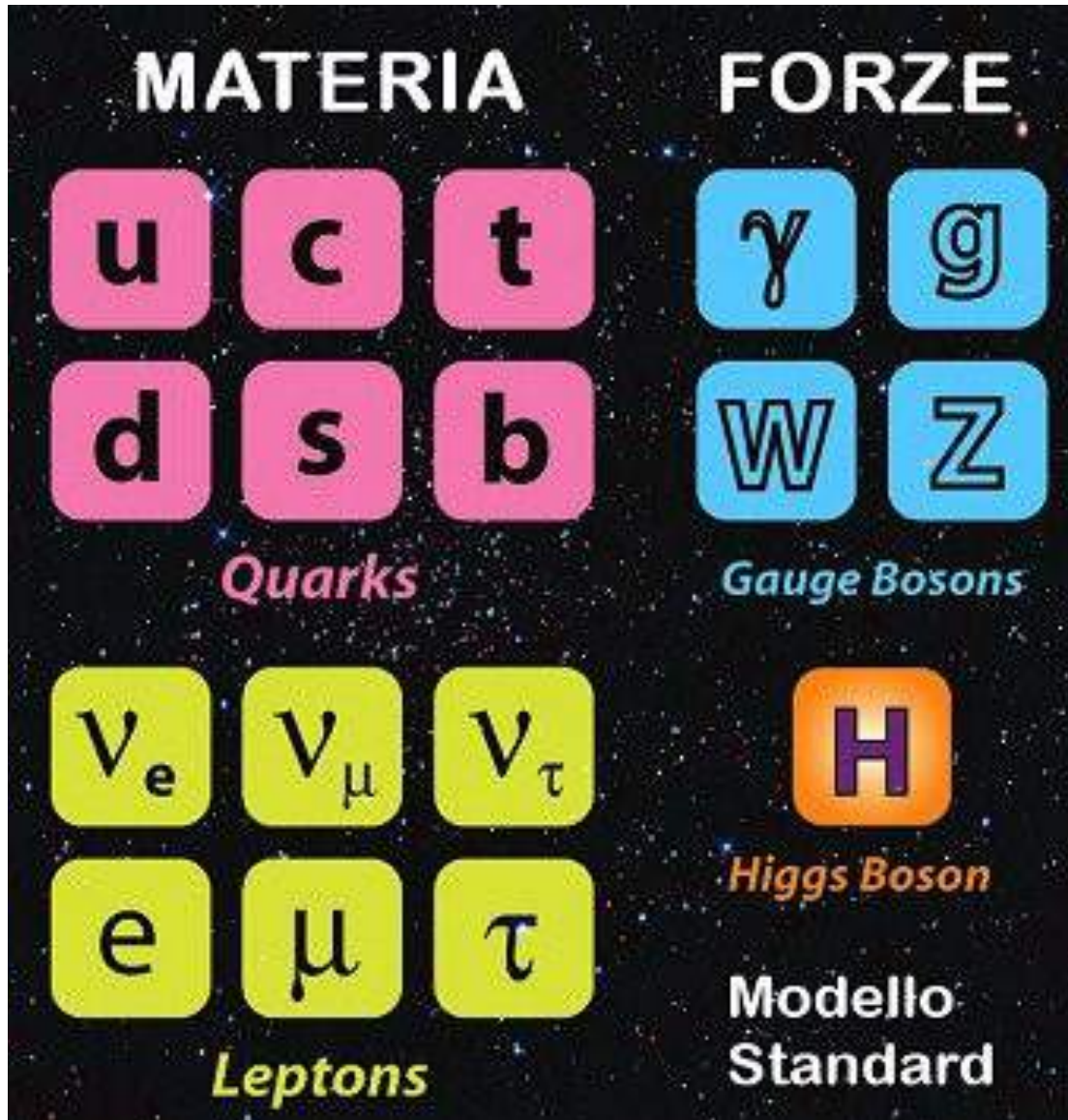


Top



Bottom

# Standard Model of Particle Physics



*Does not include gravity!*



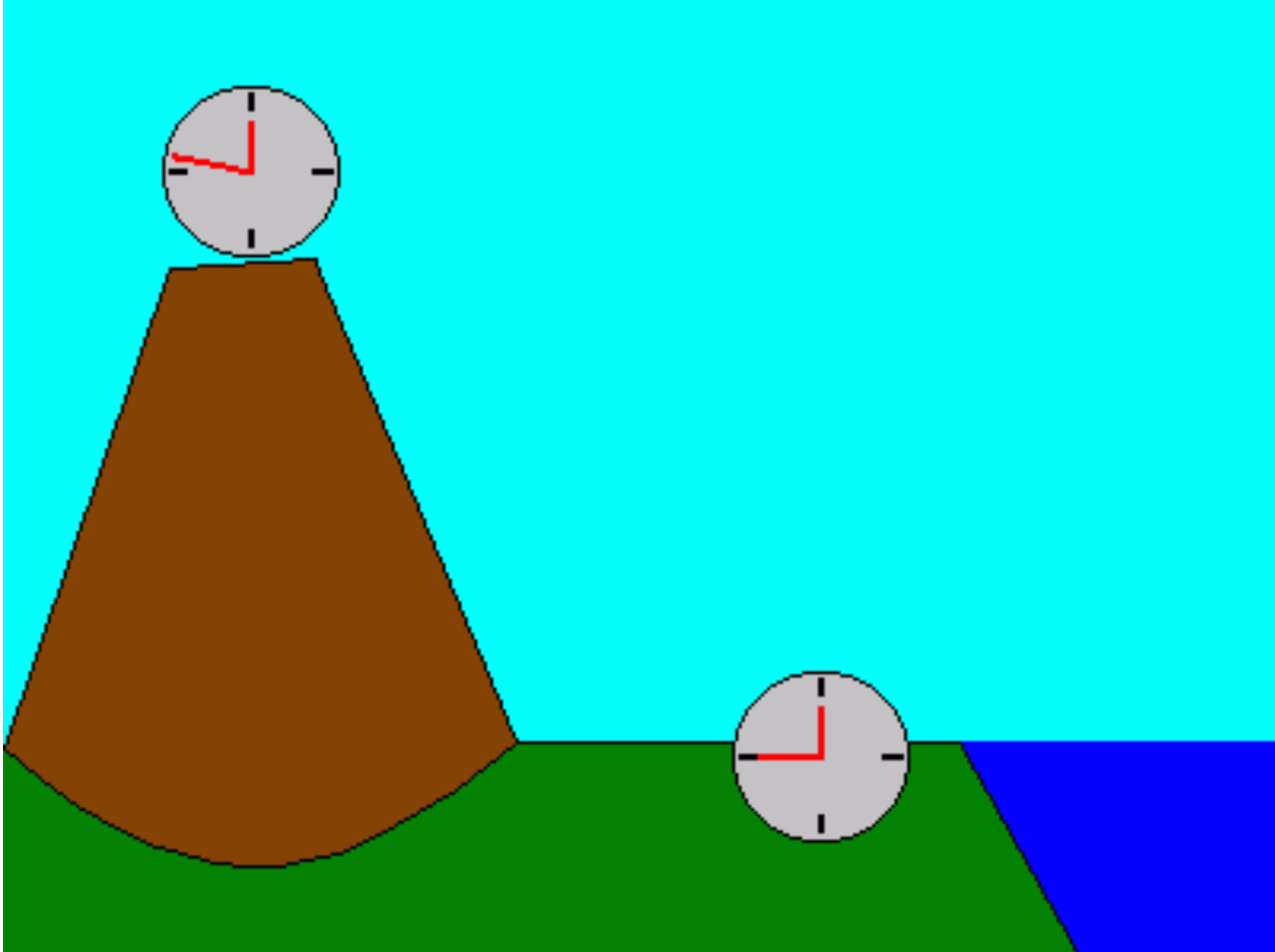
# *General relativity*



# Einstein's equations

$$R_{\mu\nu} - \frac{1}{2}g_{\mu\nu}R = \frac{8\pi G}{c^4}T_{\mu\nu}$$

**geometry** = **Mass-energy**  
**Space-time** = **distribution**





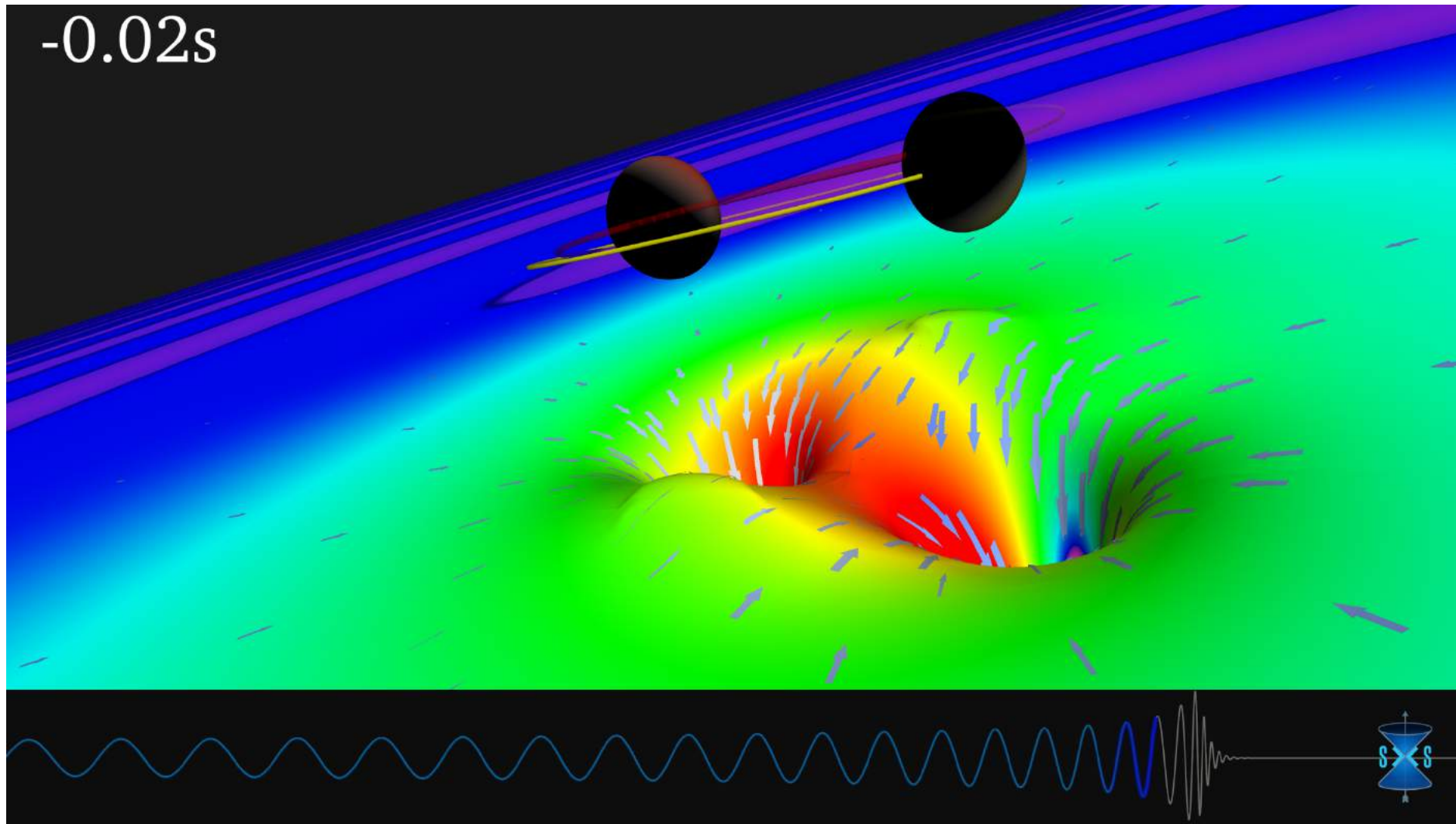




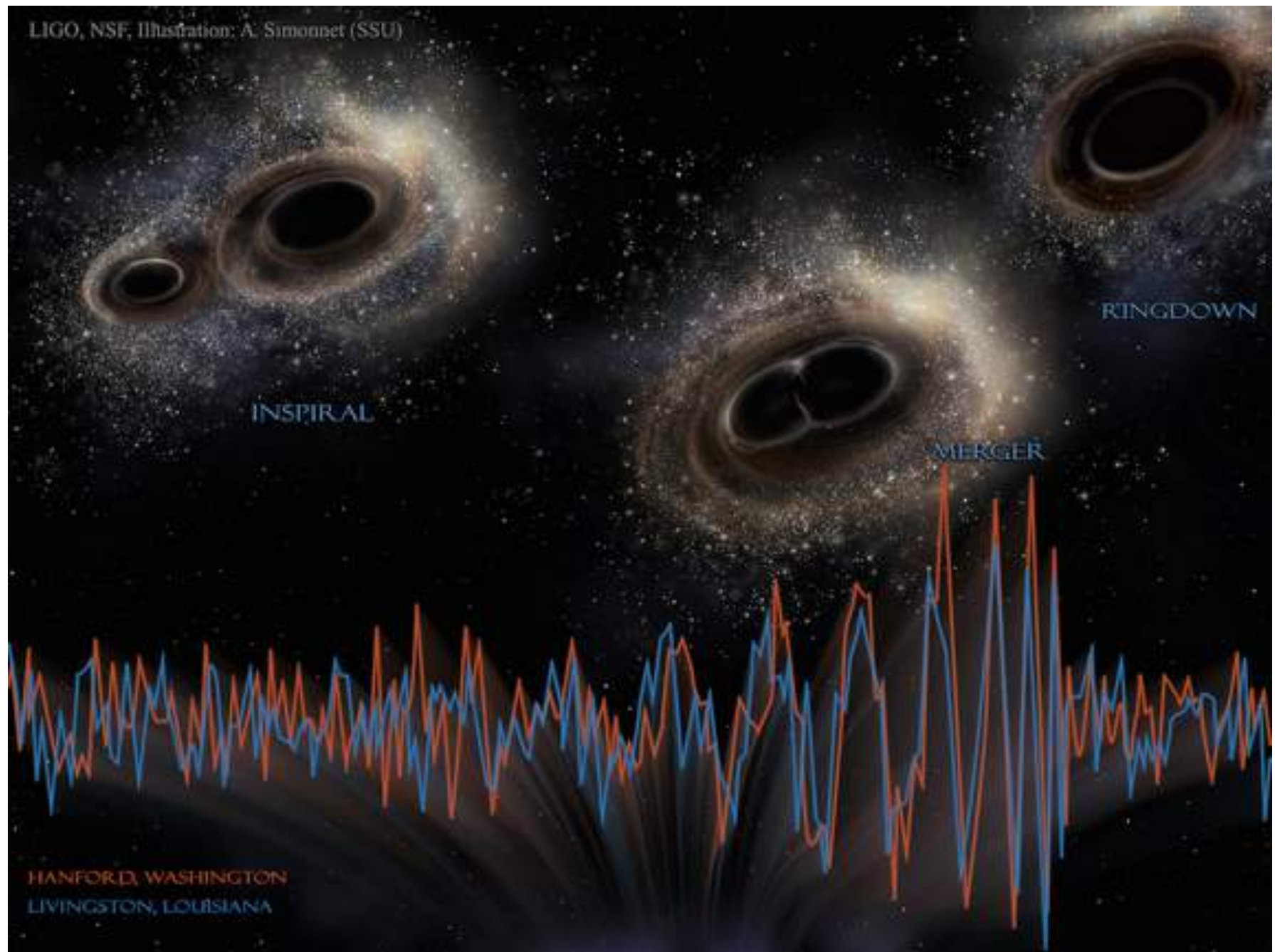
# VIRGO



-0.02s



LIGO, NSF, Illustration: A. Simonnet (SSU)



HANFORD, WASHINGTON  
LIVINGSTON, LOUISIANA



# LIGO'S GRAVITATIONAL-WAVE DETECTIONS

**GW150914**  
DISCOVERED:  
**14.09.2015**  
**1.3** BILLION  
LIGHT-YEARS  
AWAY  
**62 SOLAR  
MASSES**  
**366** KILOMETRES IN  
DIAMETER

**GW151226**  
DISCOVERED:  
**26.12.2015**  
**1.4** BILLION  
LIGHT-YEARS  
AWAY  
**21 SOLAR  
MASSES**  
**124** KILOMETRES IN  
DIAMETER

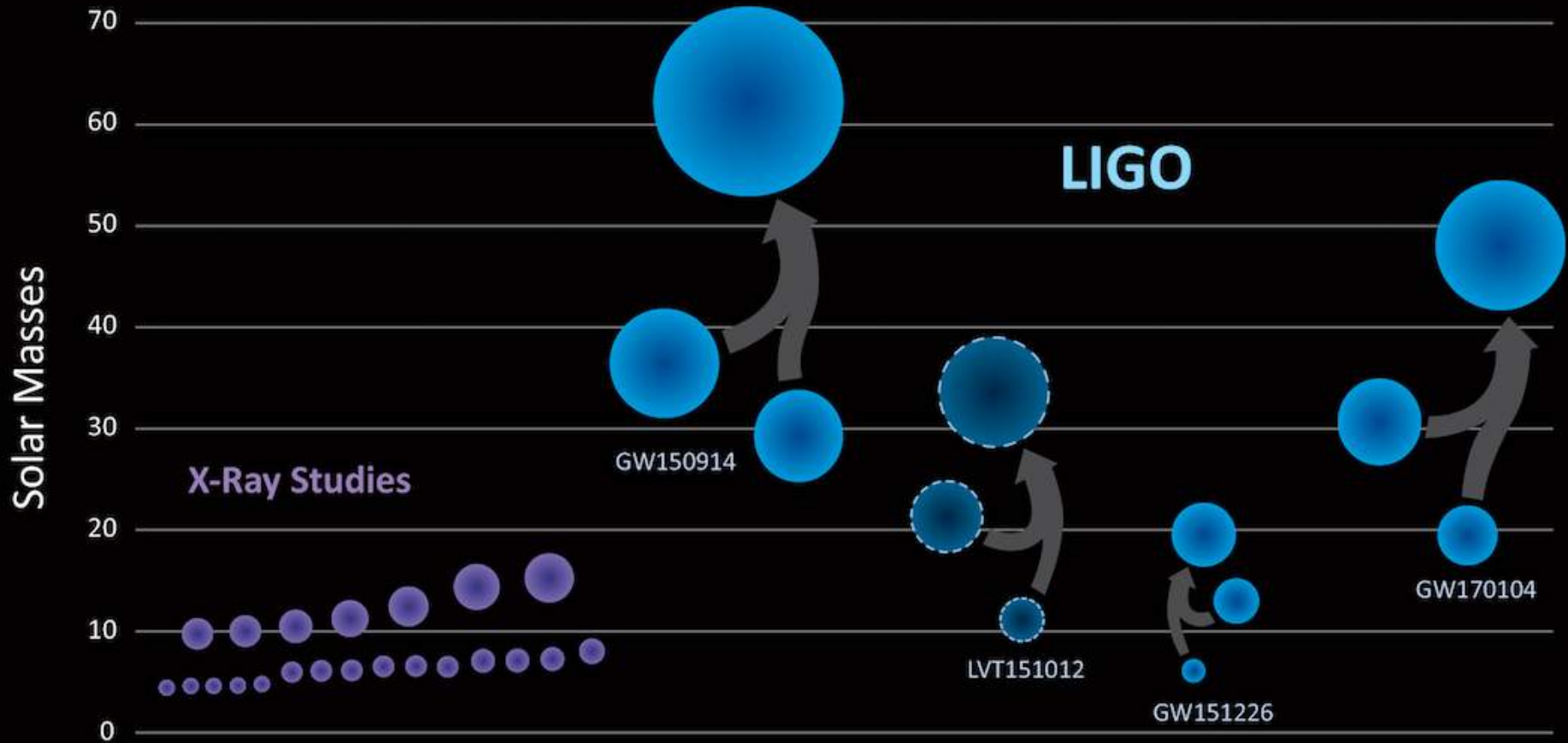
**GW170104**  
DISCOVERED:  
**04.01.2017**  
**3** BILLION  
LIGHT-YEARS  
AWAY  
**49 SOLAR  
MASSES**  
**289** KILOMETRES IN  
DIAMETER



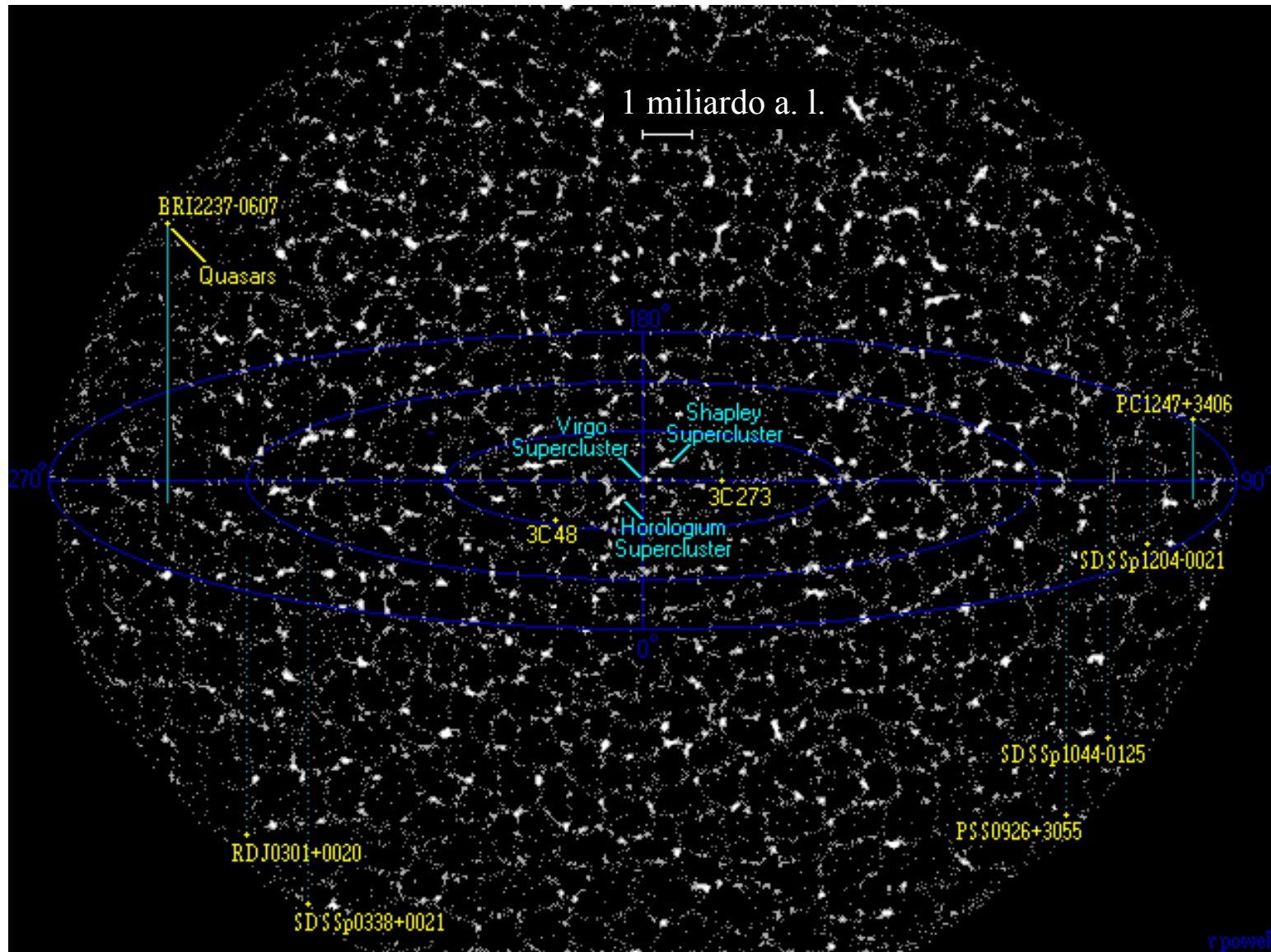
**YOU ARE  
HERE**

**DID YOU KNOW ?**  
THE SOLAR MASS IS  
A STANDARD UNIT OF MASS  
IN ASTRONOMY  
IT IS EQUAL TO  
THE MASS OF THE SUN  
EQUAL TO APPROXIMATELY  
 **$1.99 \times 10^{30}$  KG**

# Black Holes of Known Mass







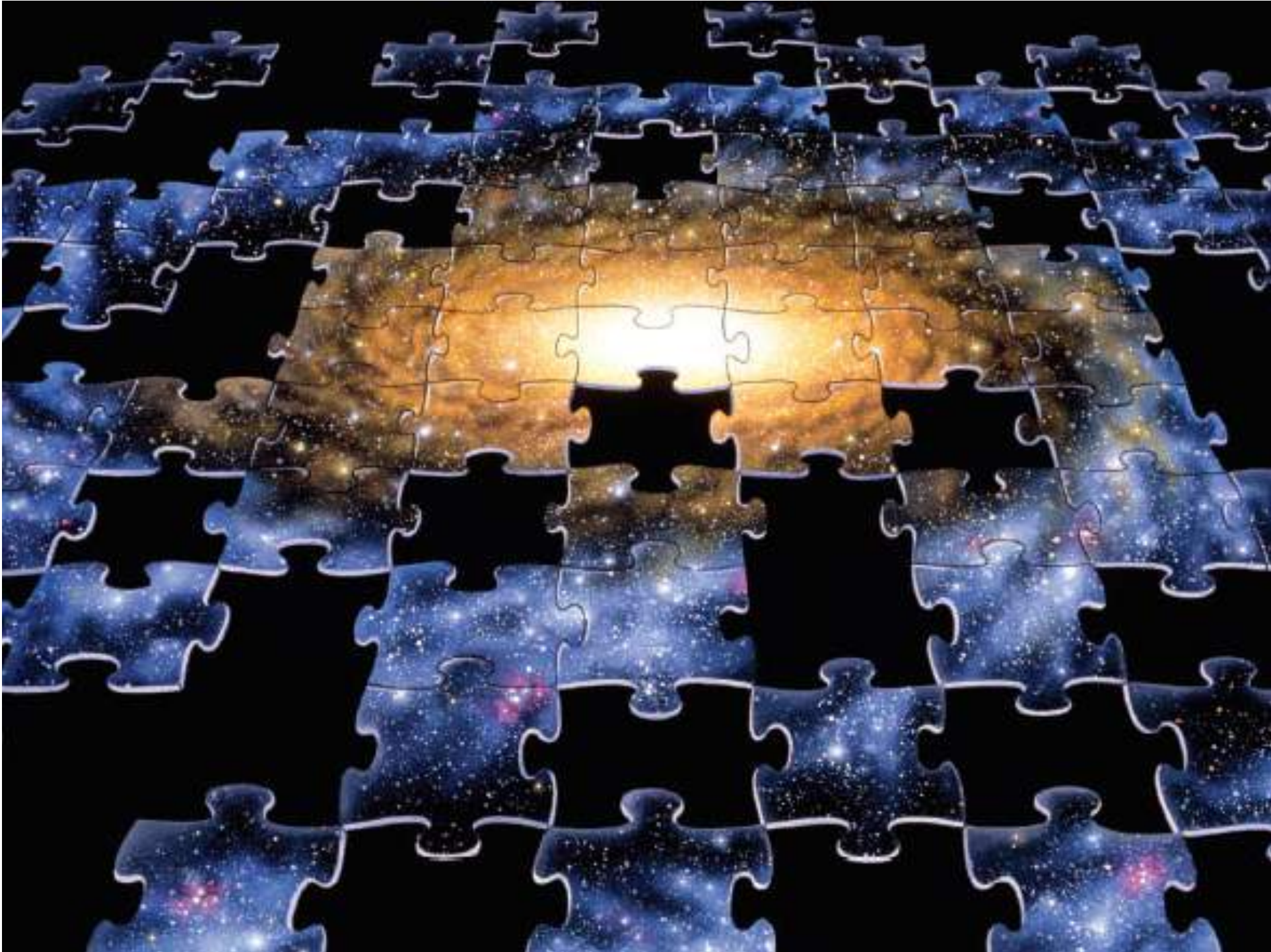
Zoom In x15

Zoom Out



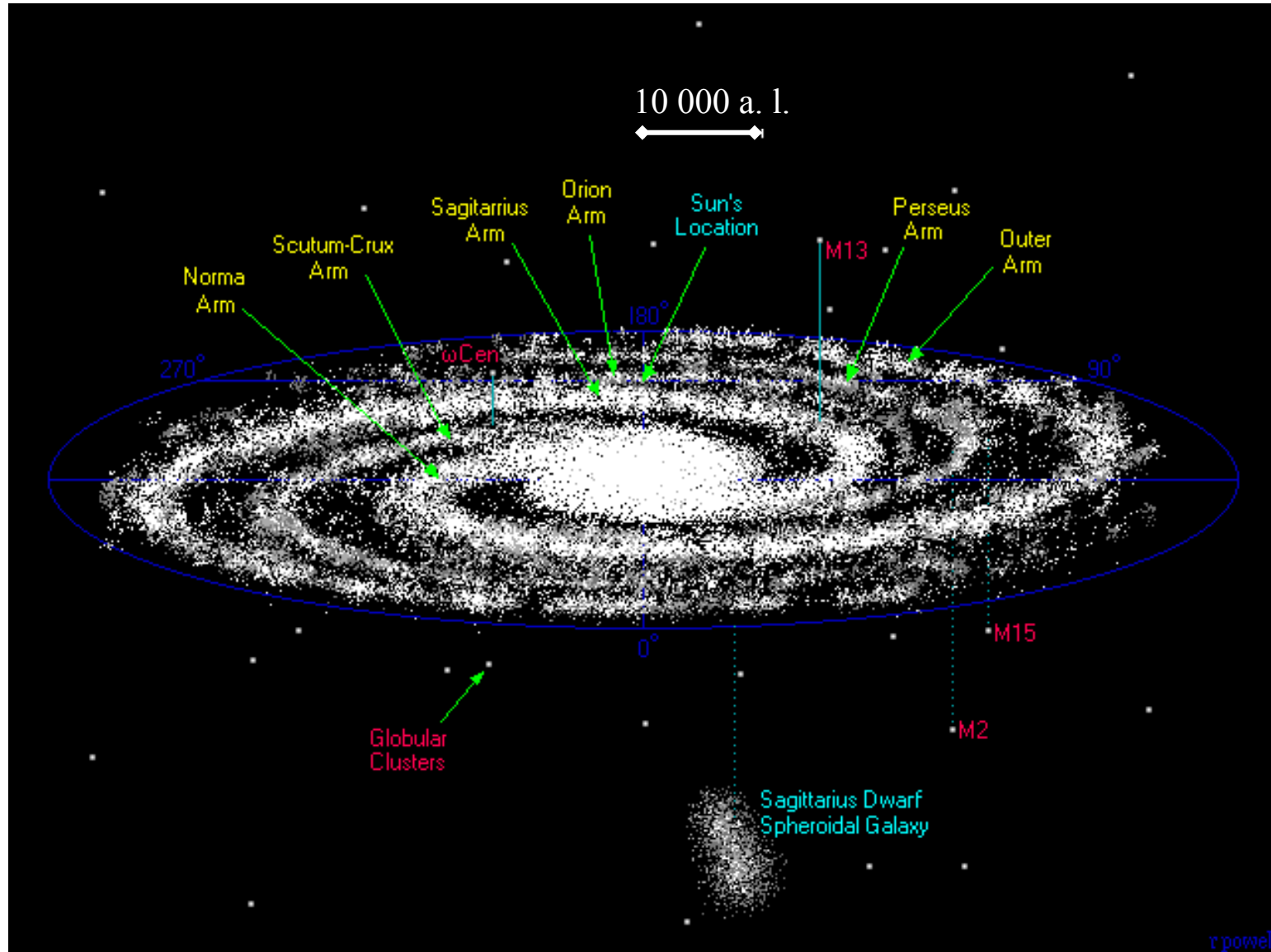
Did we understand the Universe?





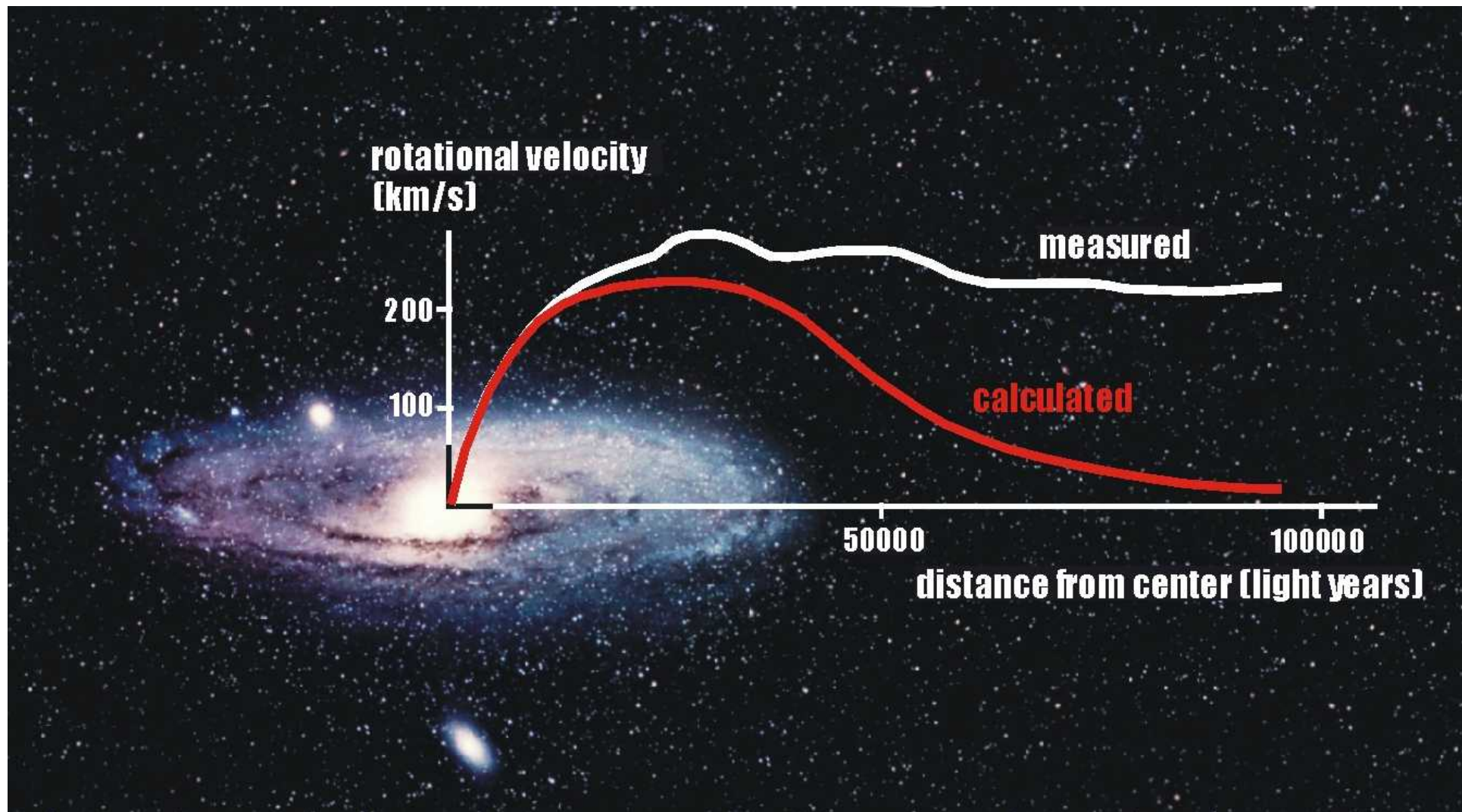
# Dark matter and dark energy





Zoom In x10

Zoom Out x10

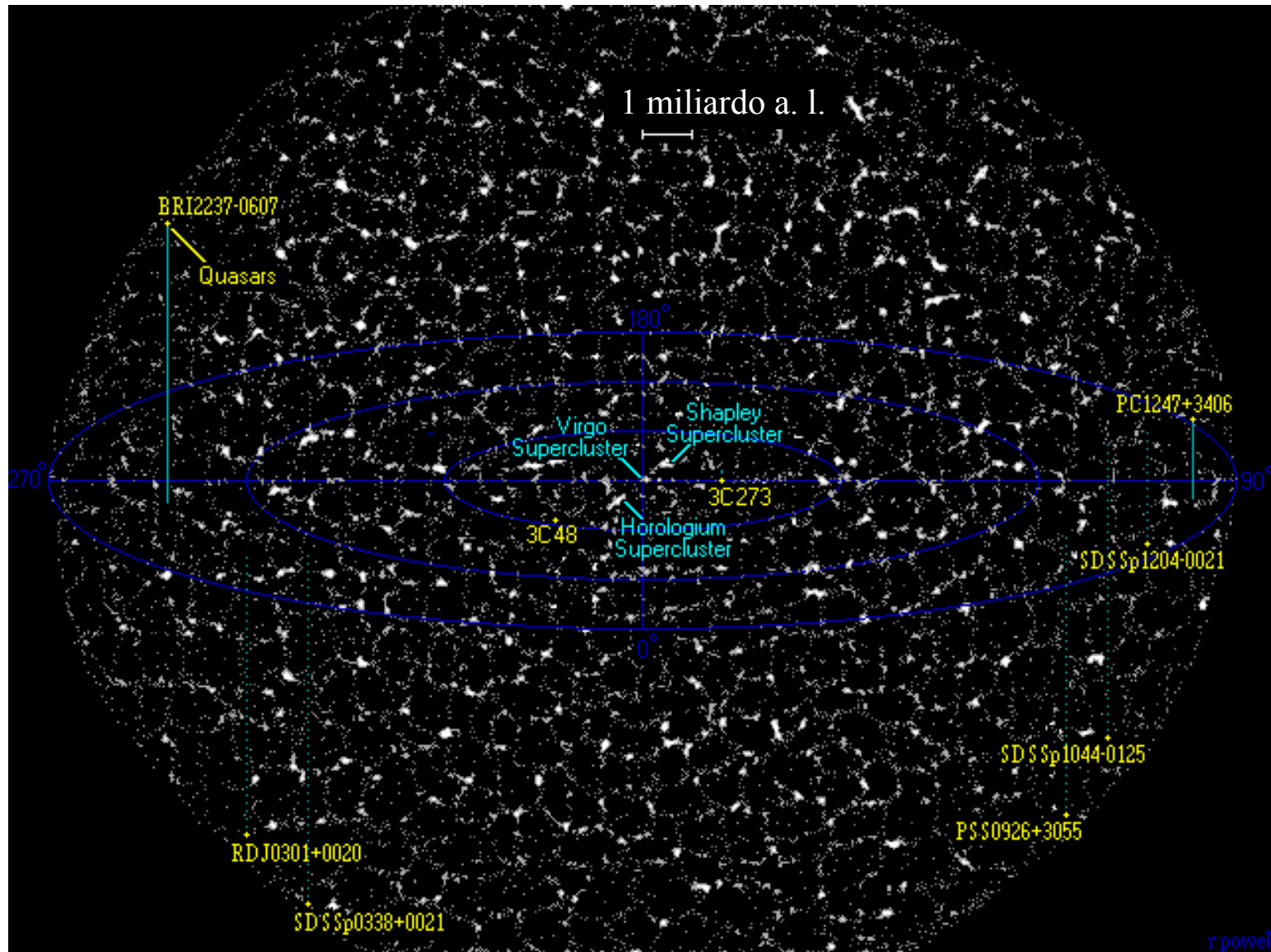




**FOUND**

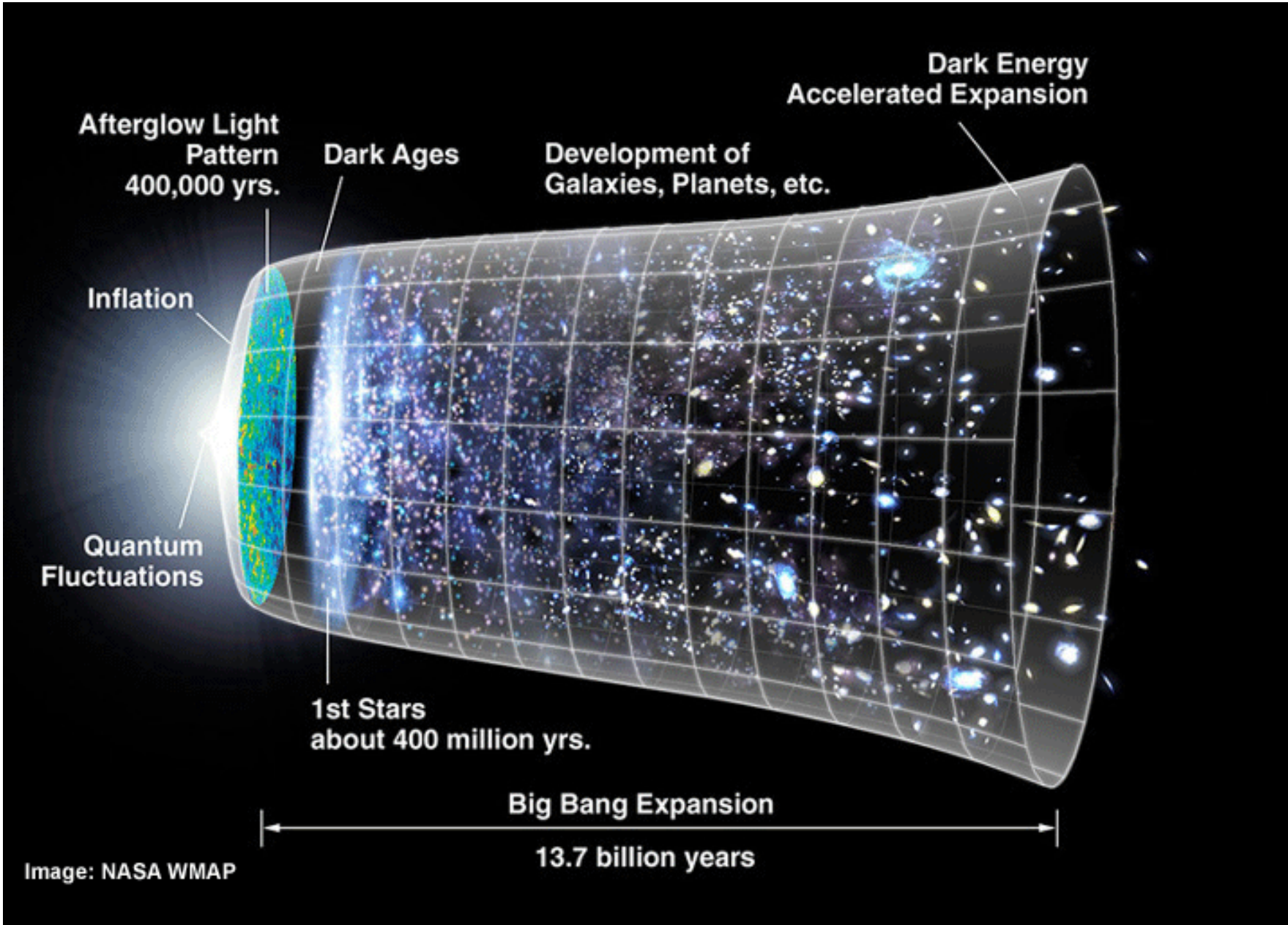
**99.9%**

**DARK MATTER  
GALAXY**

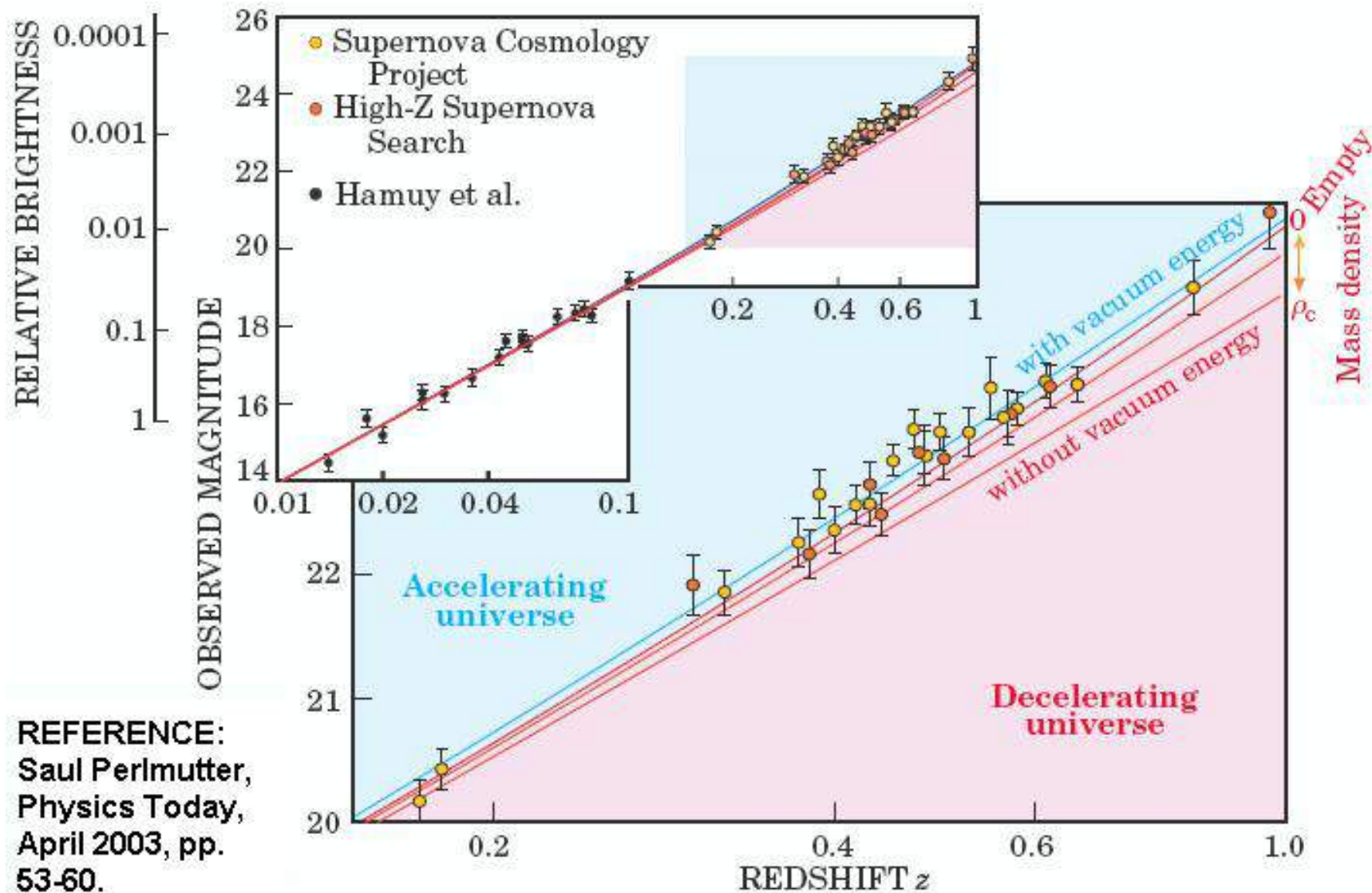


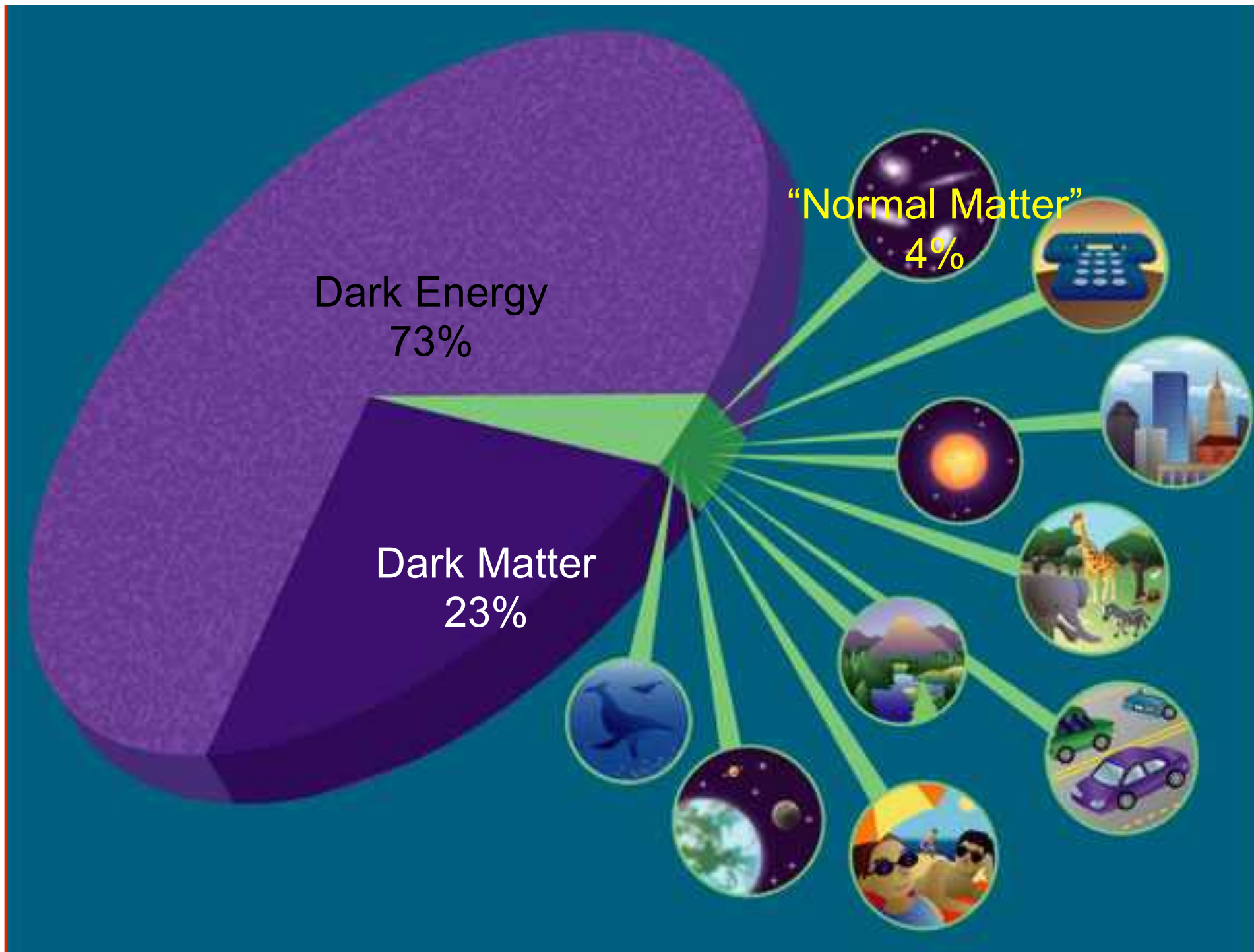
Zoom In x15

Zoom Out

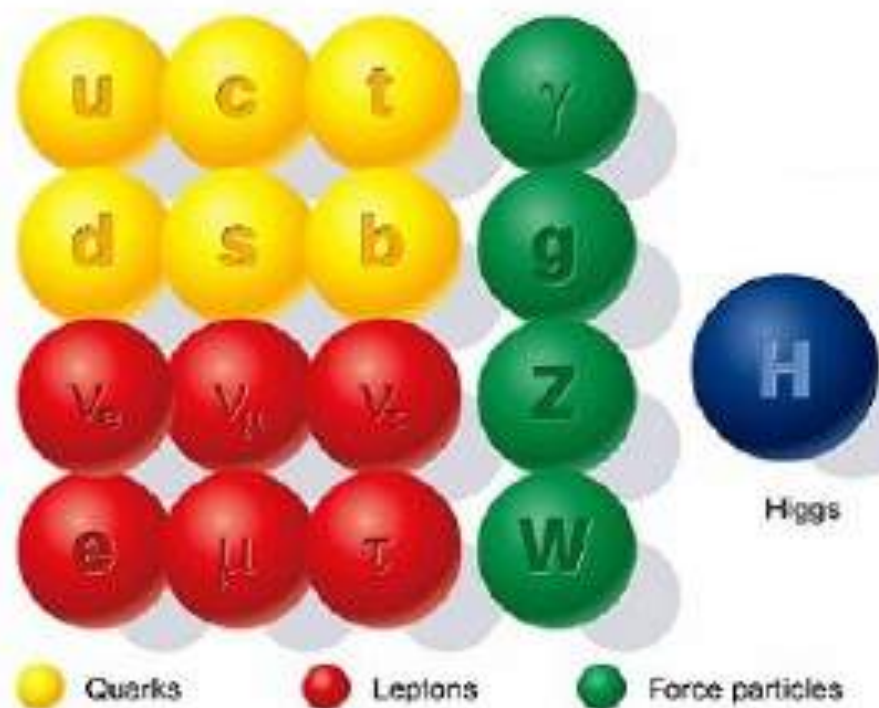




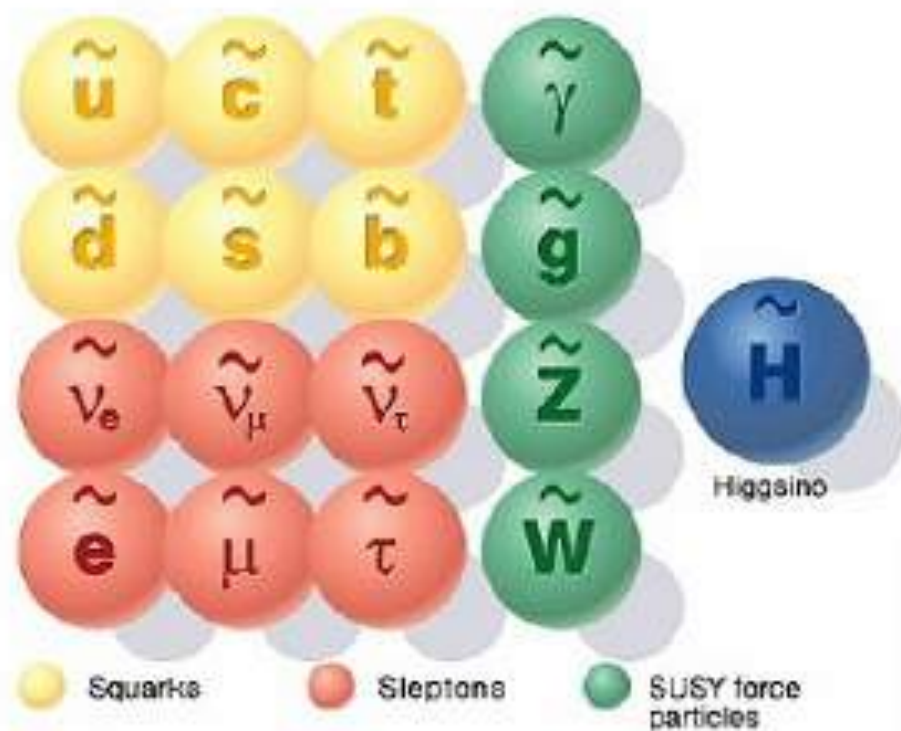




# SUPERSYMMETRY

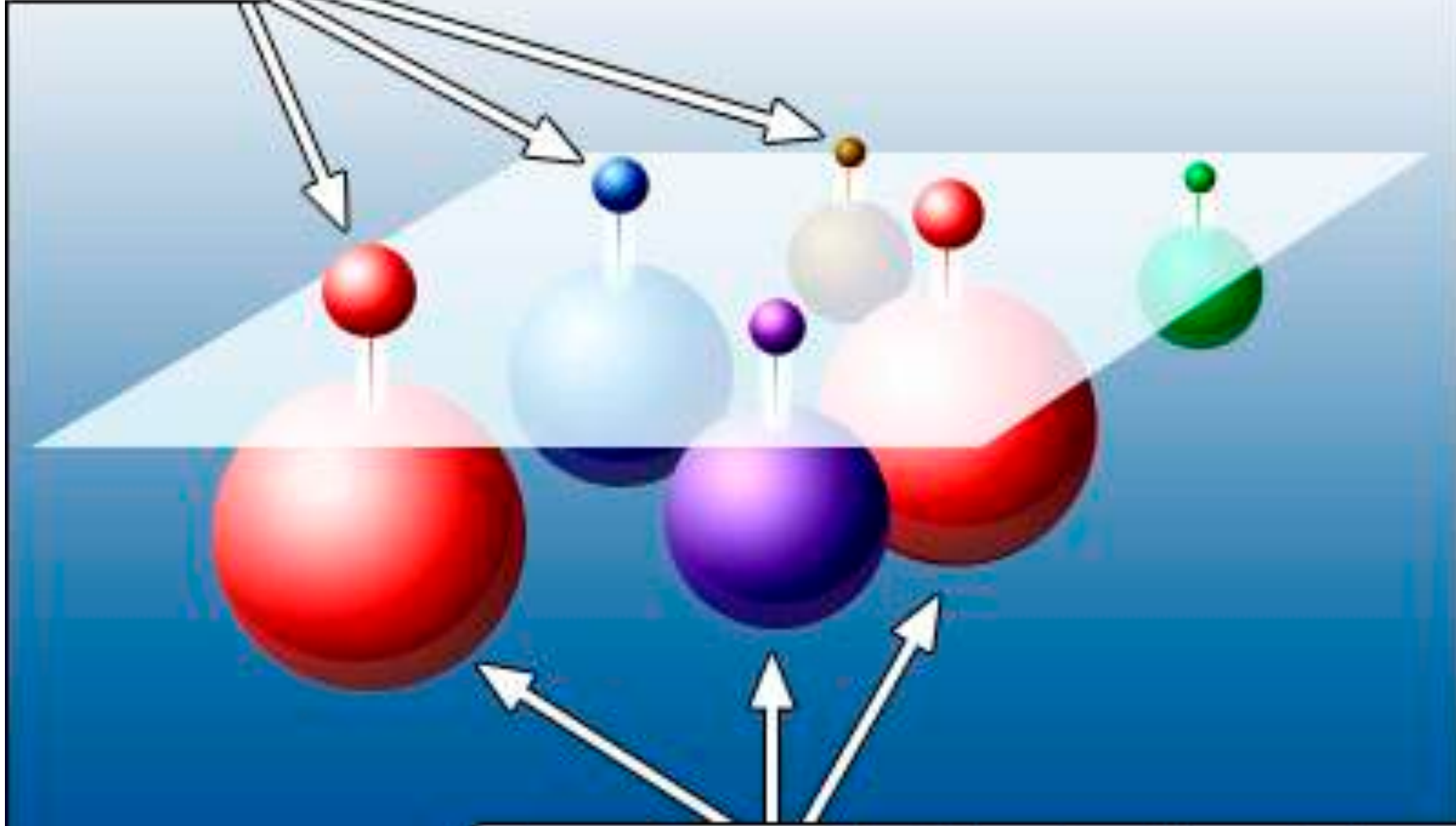


Standard particles



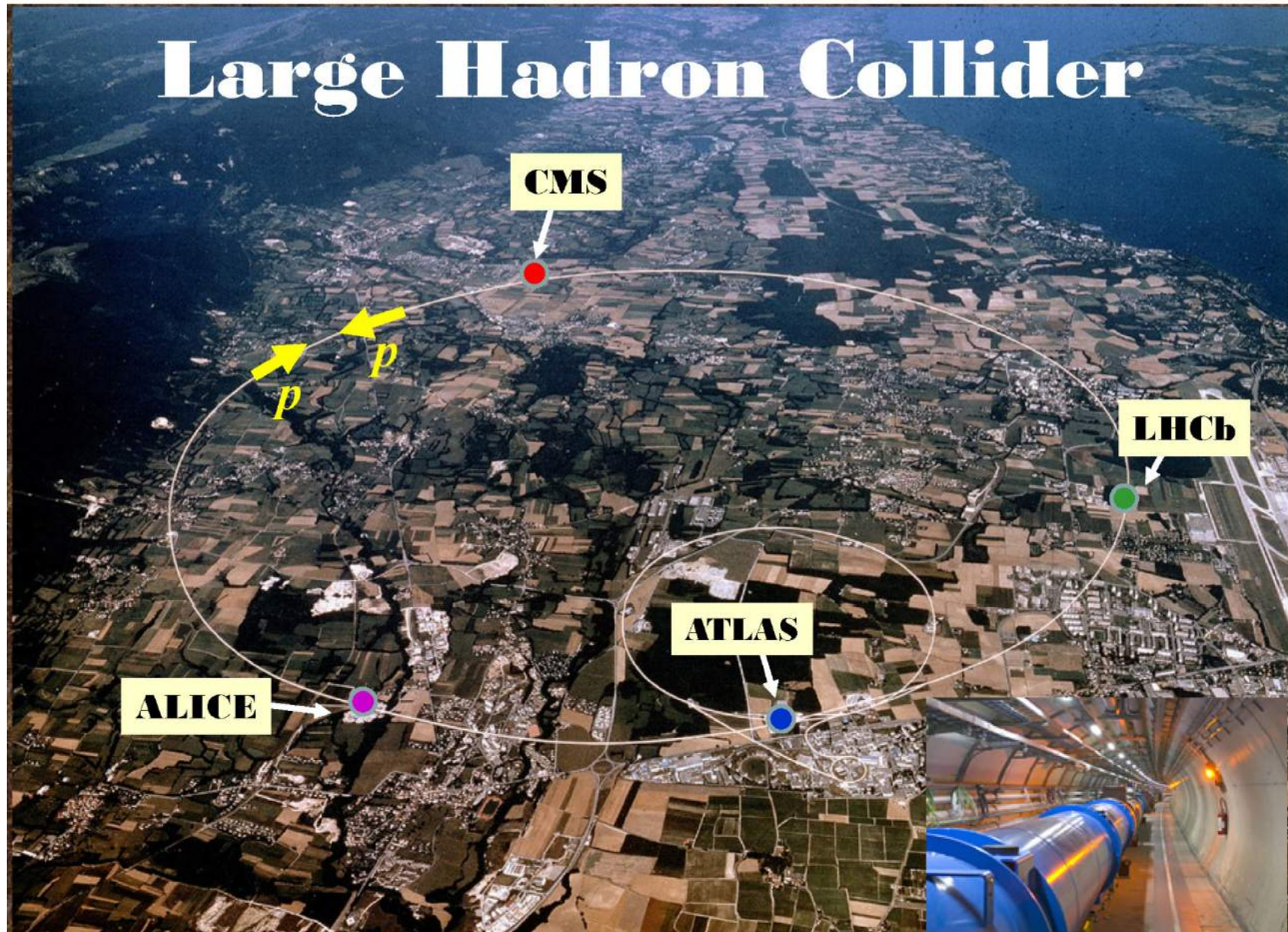
SUSY particles

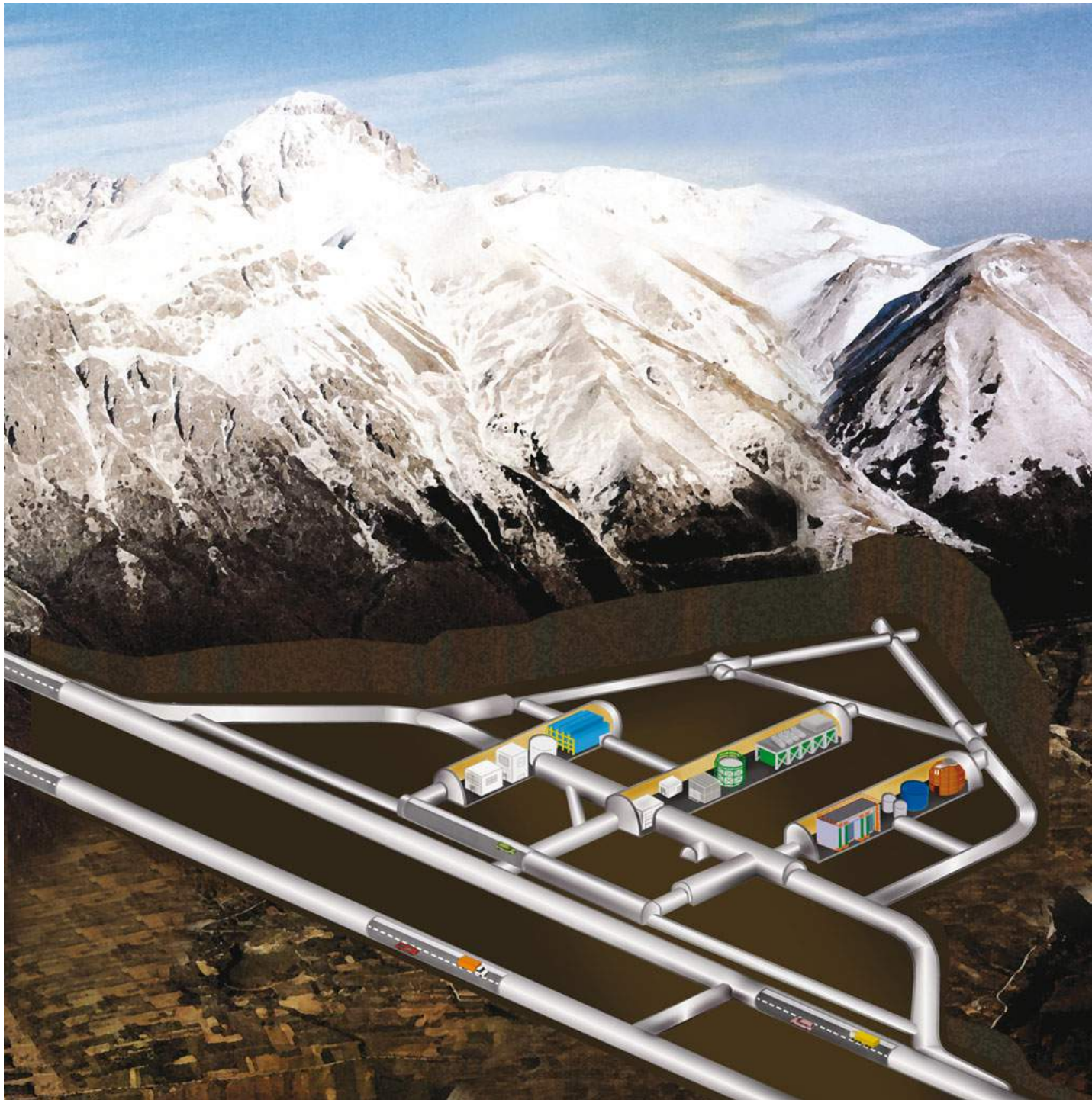
Particles



Supersymmetric "shadow" particles

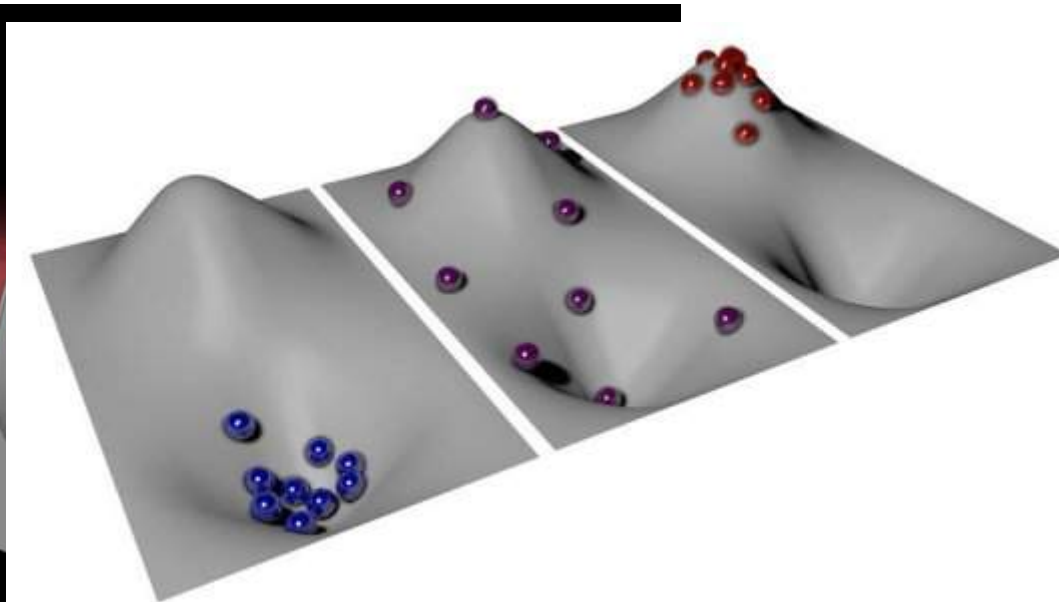
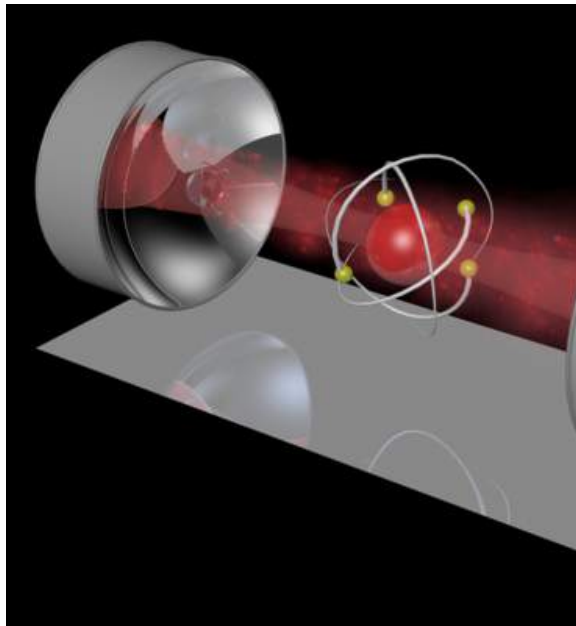
A caccia di particelle di materia oscura





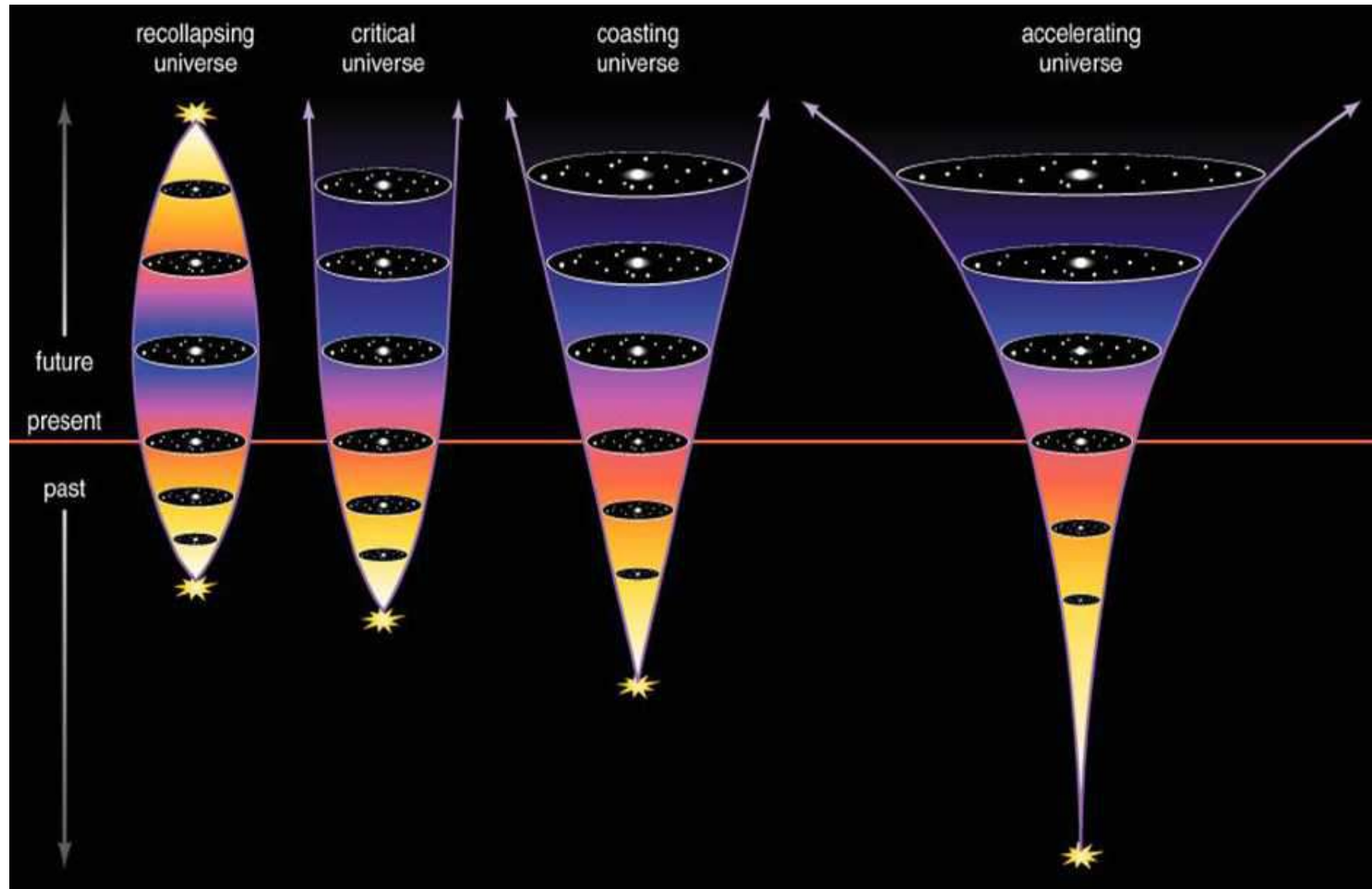


**Dark energy???**  
**Cosmological constant**  
**Vacuum energy**  
**Something else?**  
**Below 0 K**





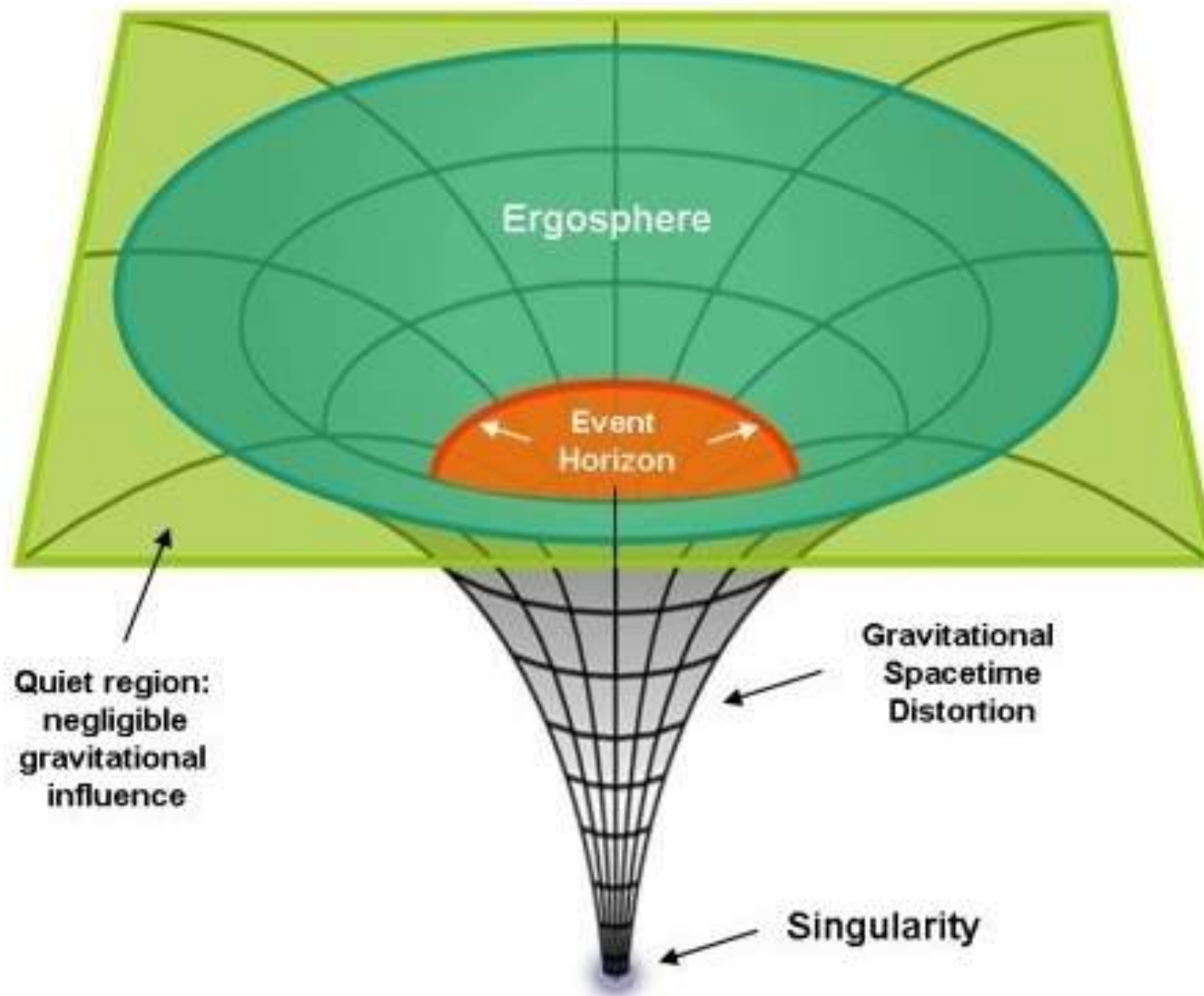
# How Universe will evolve?



# Jump into a black hole?



# Black Hole Regions

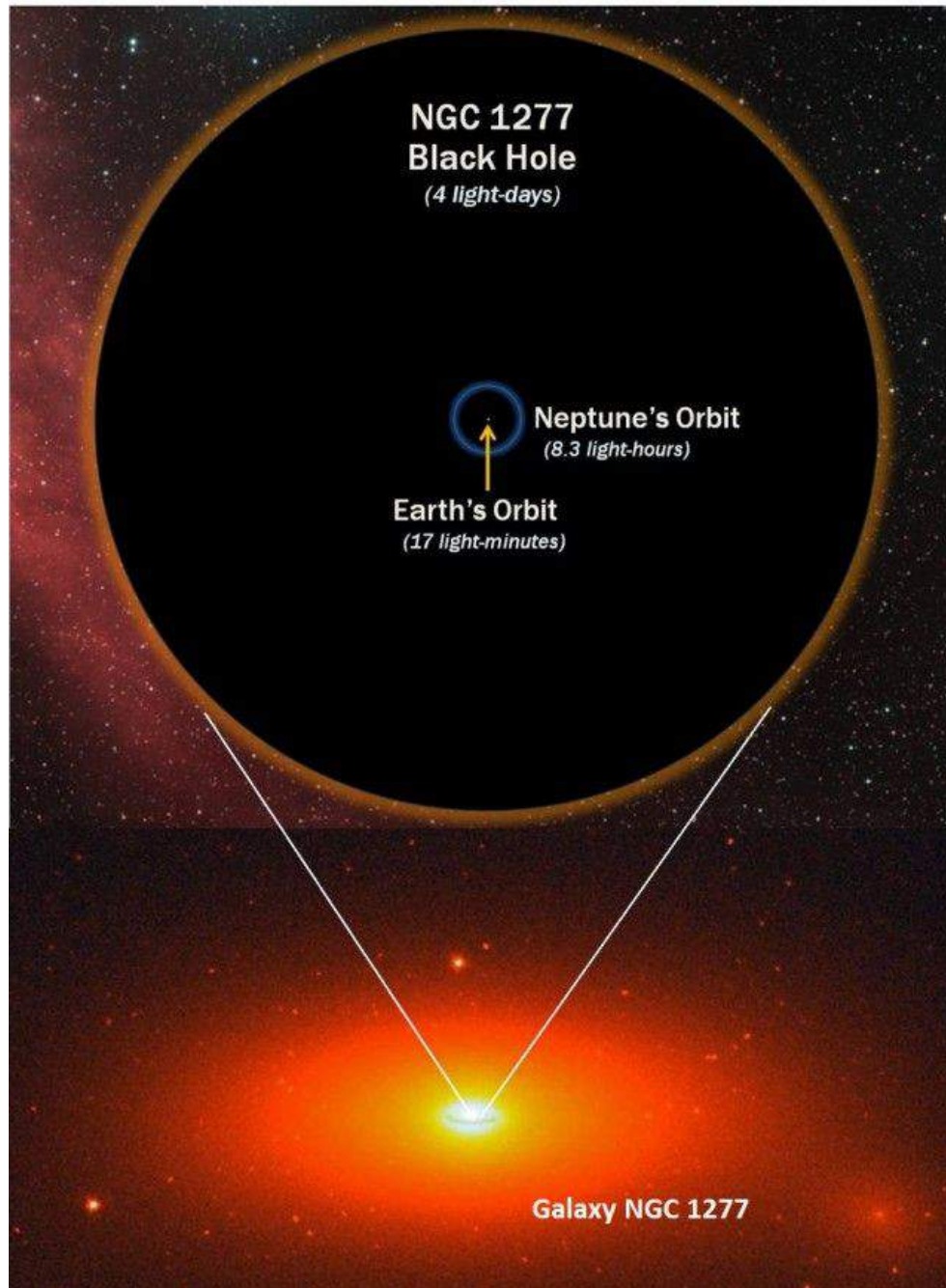


# Spaghettification!

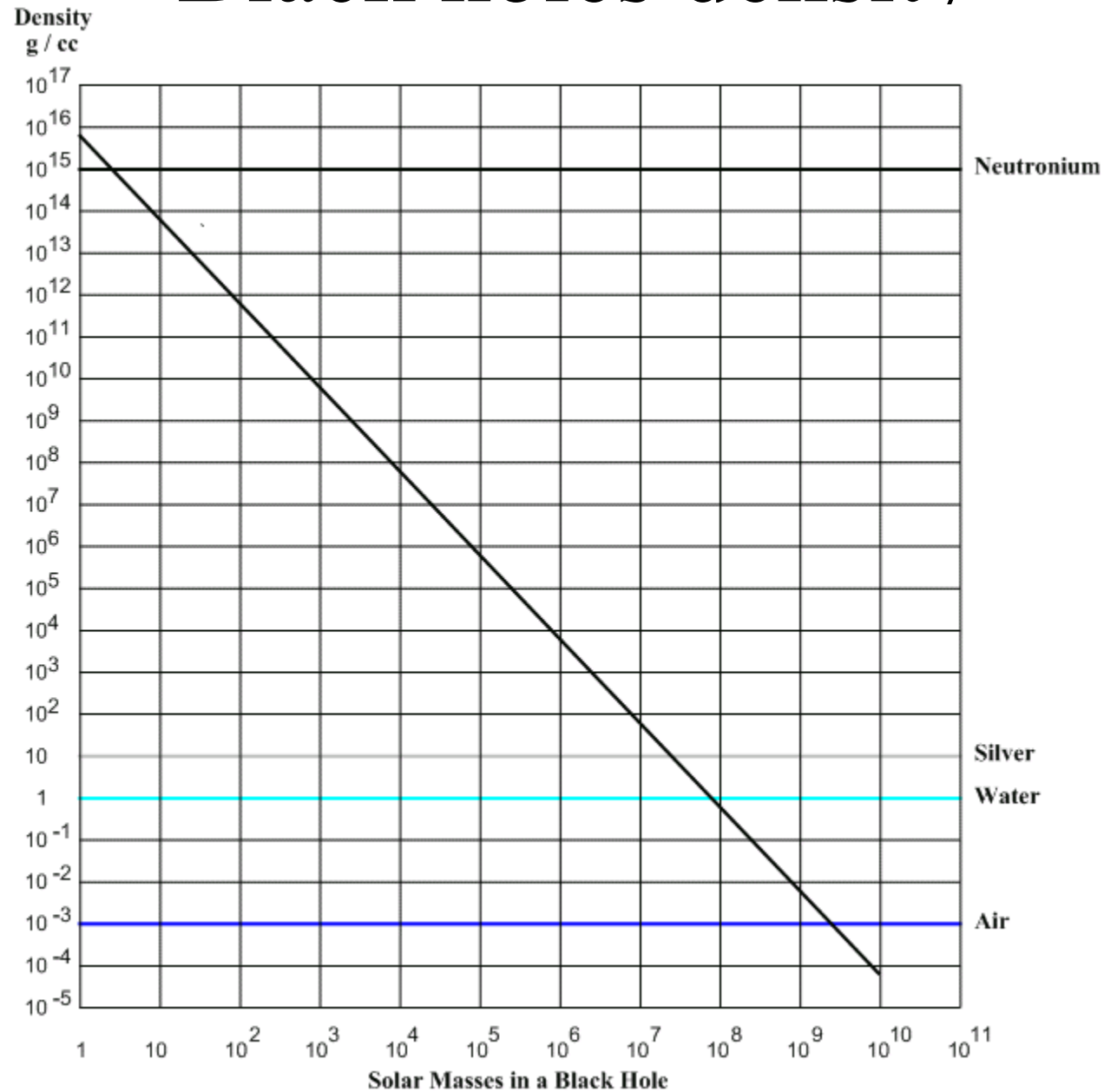


## To Black Hole

Black Hole – mass about 17 billion times sun mass



# Black holes density



# Interstellar travels?

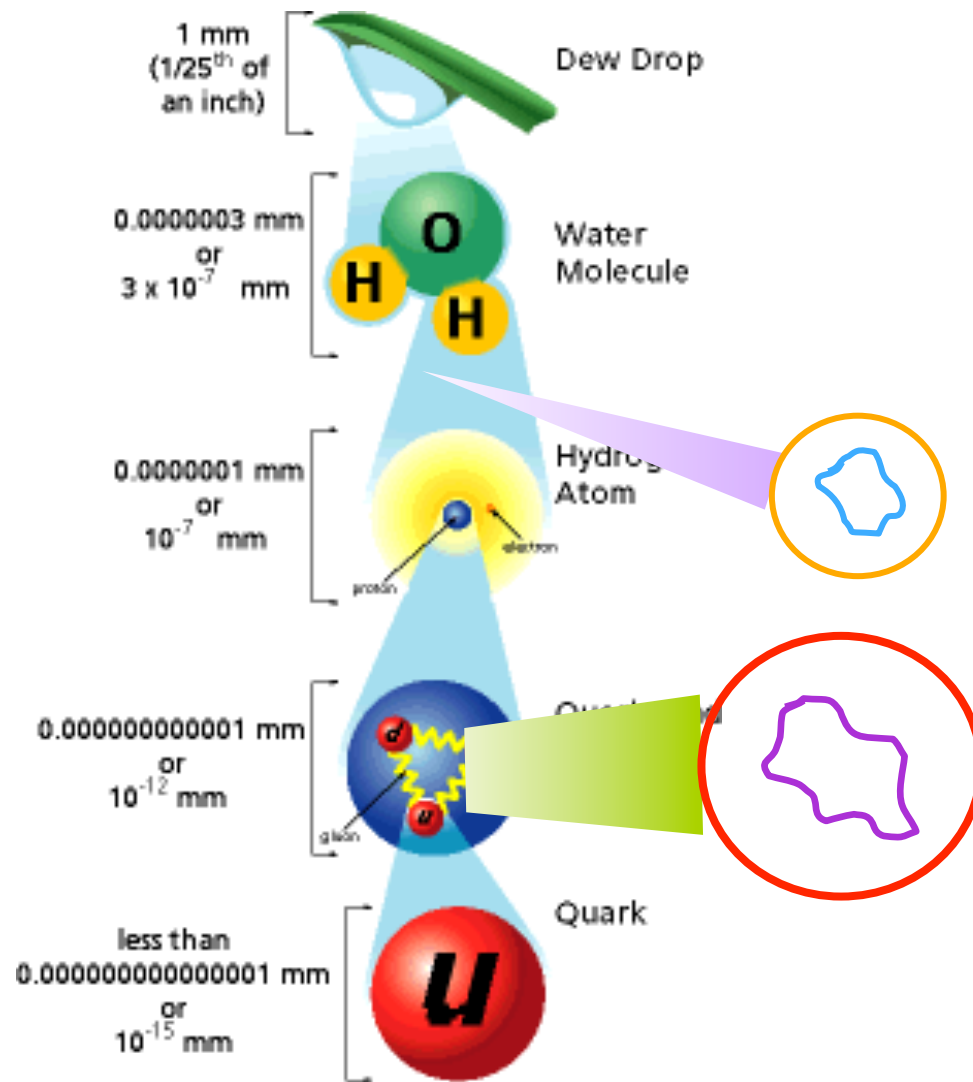


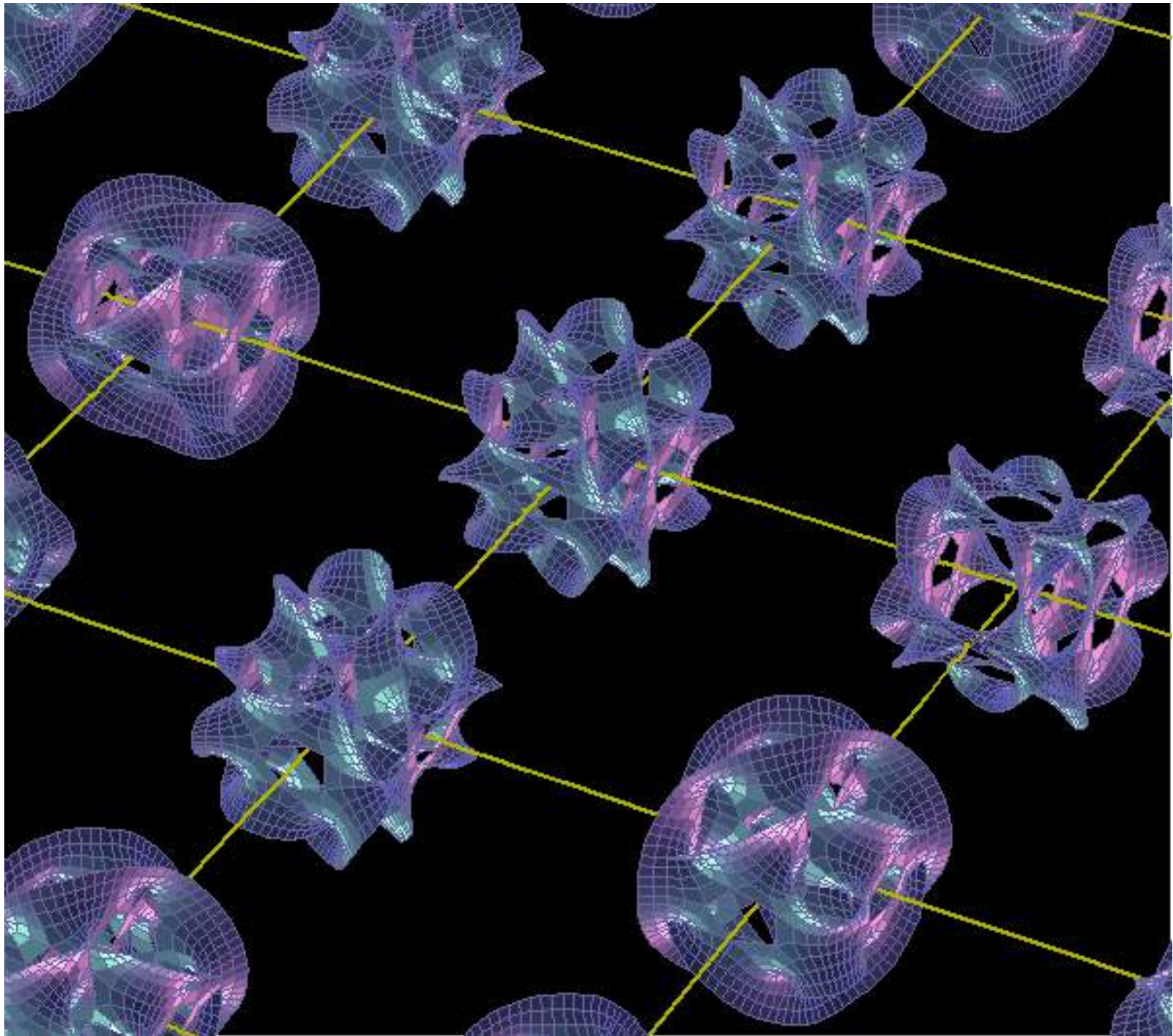
# Quantum gravity'!





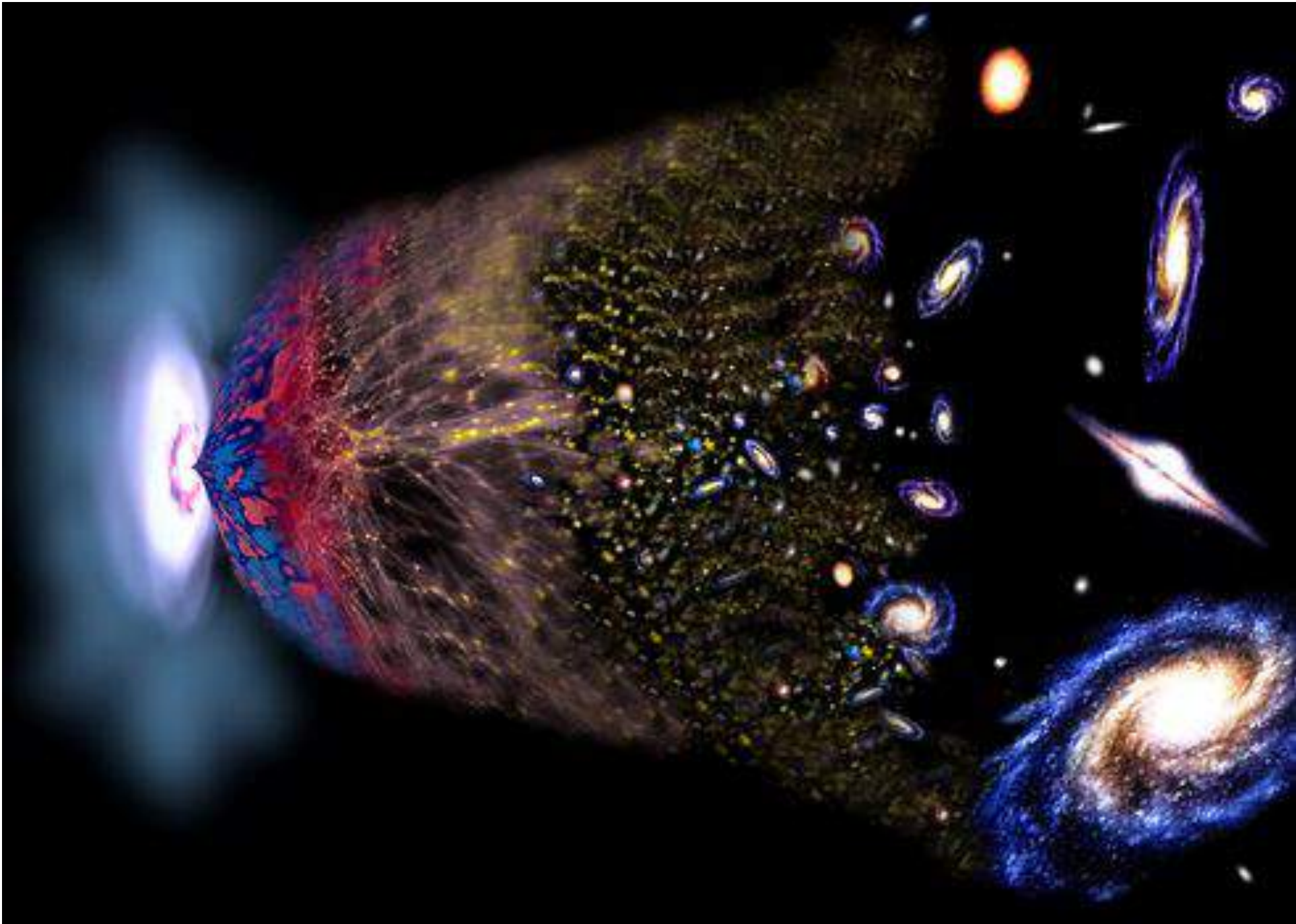
# String theory





$10^{500}$  parallel Universes!!!







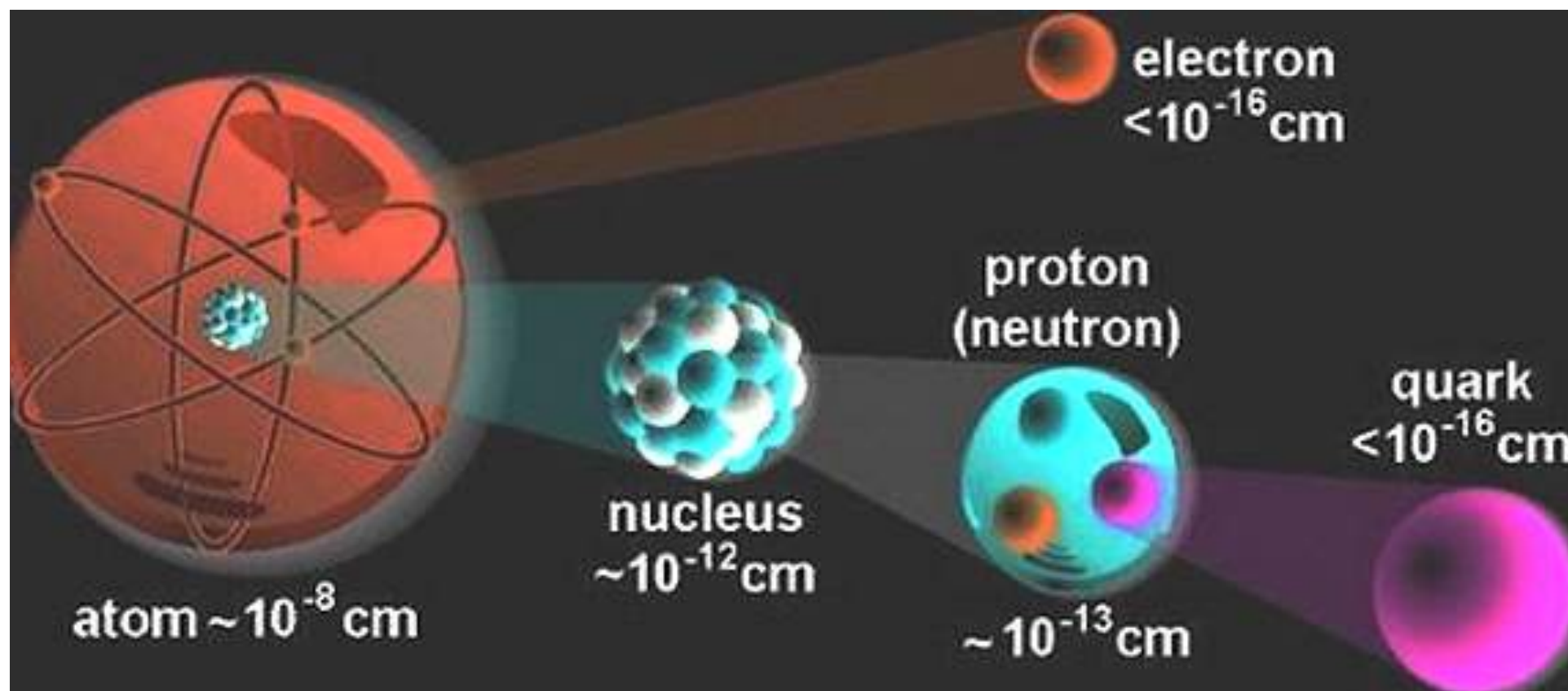
ON THAT SIGNAL IN THE SKY,  
WE CAN TRACE OUR ORIGIN:


WE WERE LIGHT ONCE.

THEN WE WERE RIPPLES  
IN TEMPERATURE THAT  
BECAME STARS...

GALAXIES, MATTER...

...AND LIFE.





If we want to solve  
a problem that we  
have never solved  
before, we must  
leave the door to  
the unknown ajar.

Richard Feynman







Catalina Curceanu (Facebook)

Catalina.Curceanu@LNF.INFN.IT

14 Agosto 2017: LIGO e VIRGO - **GW170814** –  
2 buchi neri distanti 1.8 miliardi anni luce  
(31, 25 Masse Solari -> 53 masse solari)

