Dark Matter: A Glimpse into the Invisible

Francisco Xavier Linares Cedeño

General Colloquium/Student-Oriented
Universidad de Deusto

Bilbao, 5 February 2026

This work has received funding from the PID2023-146872OB-I00-DyCMaMod

Dark Matter: A Glimpse into the Invisible

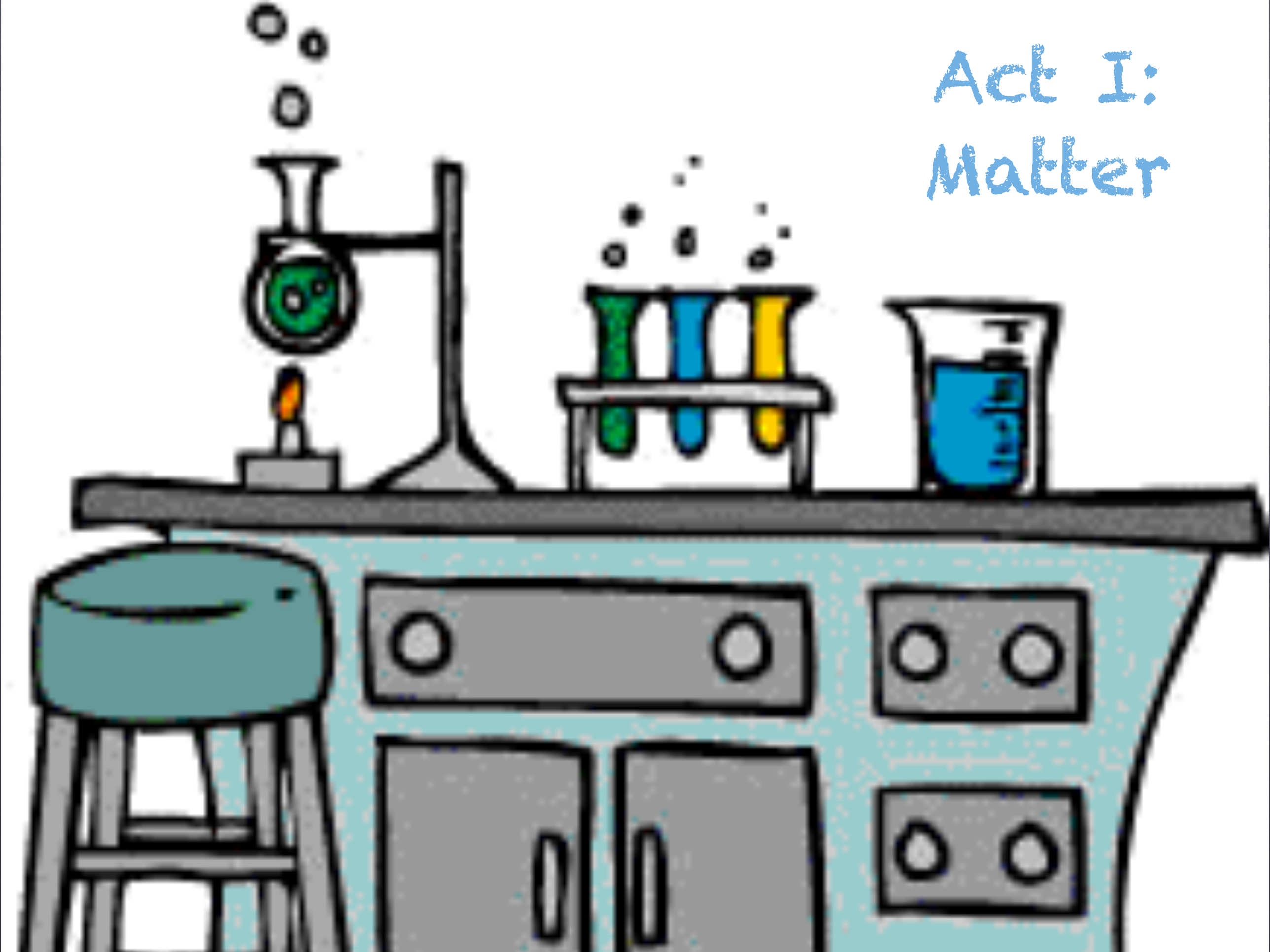
Francisco Xavier Linares Cedeño

General Colloquium/Student-Oriented
Universidad de Deusto

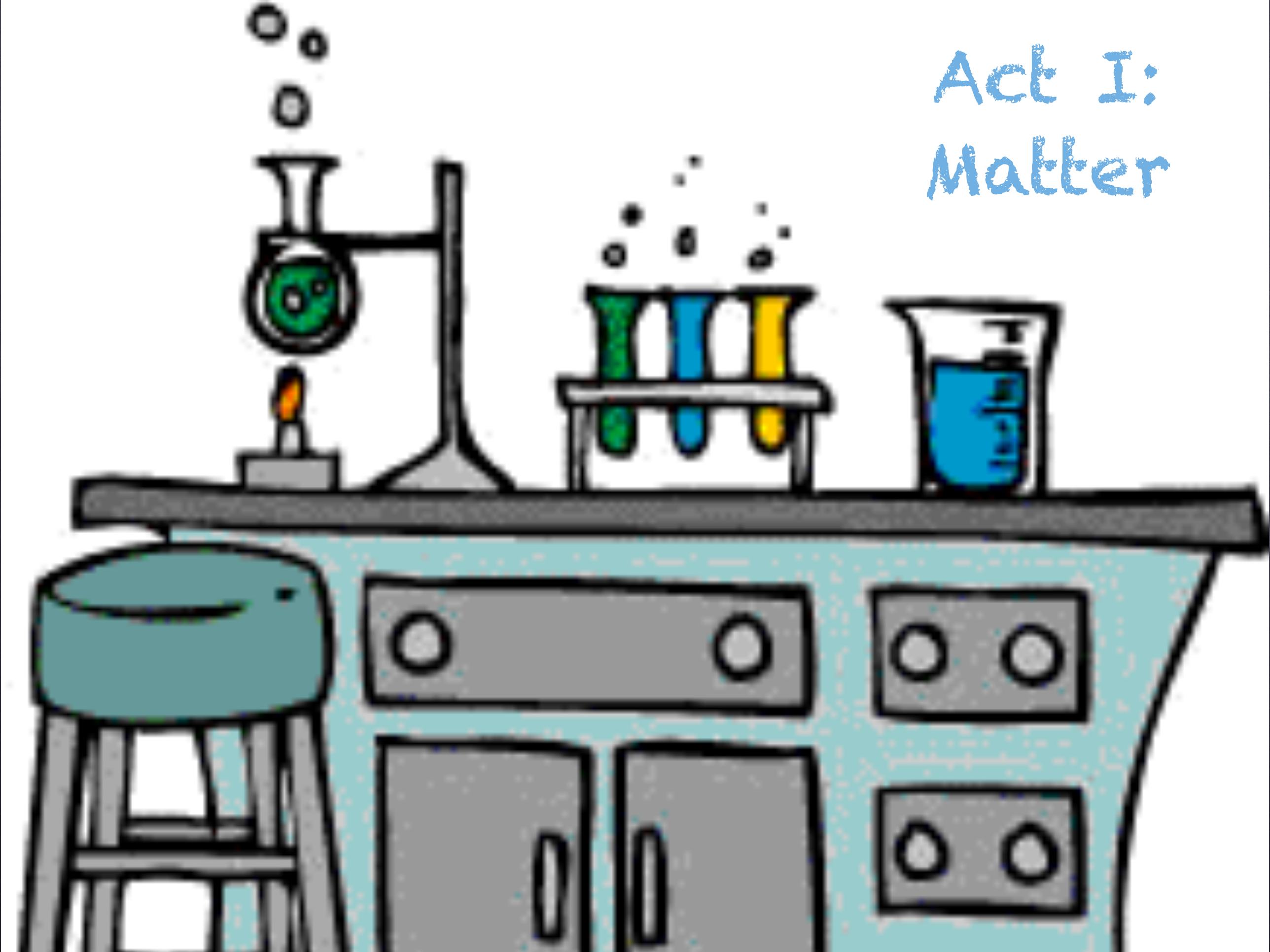
Bilbao, 5 February 2026

This work has received funding from the PID2023-146872OB-I00-DyCMaMod

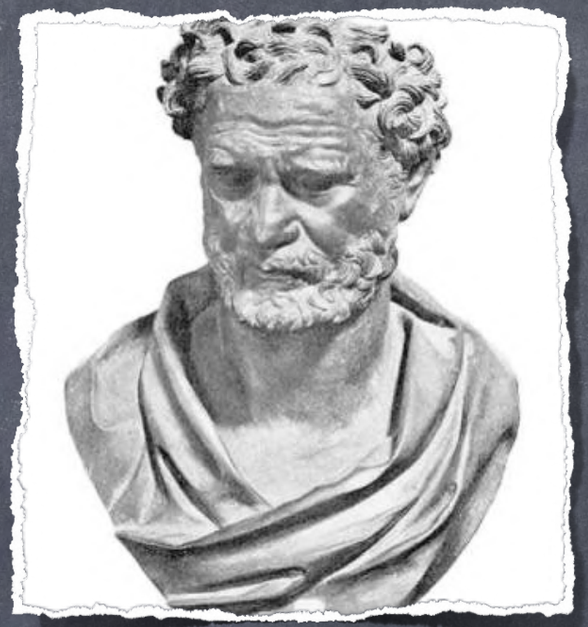
Act I: Matter



Act I: Matter



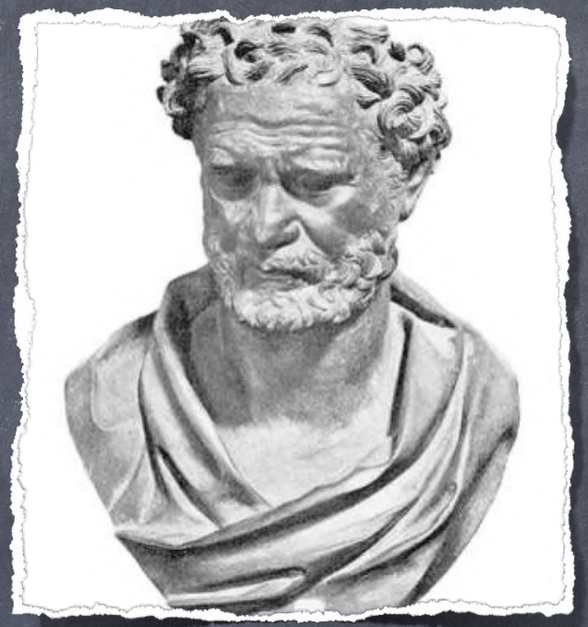
What is matter made of?



Democritus

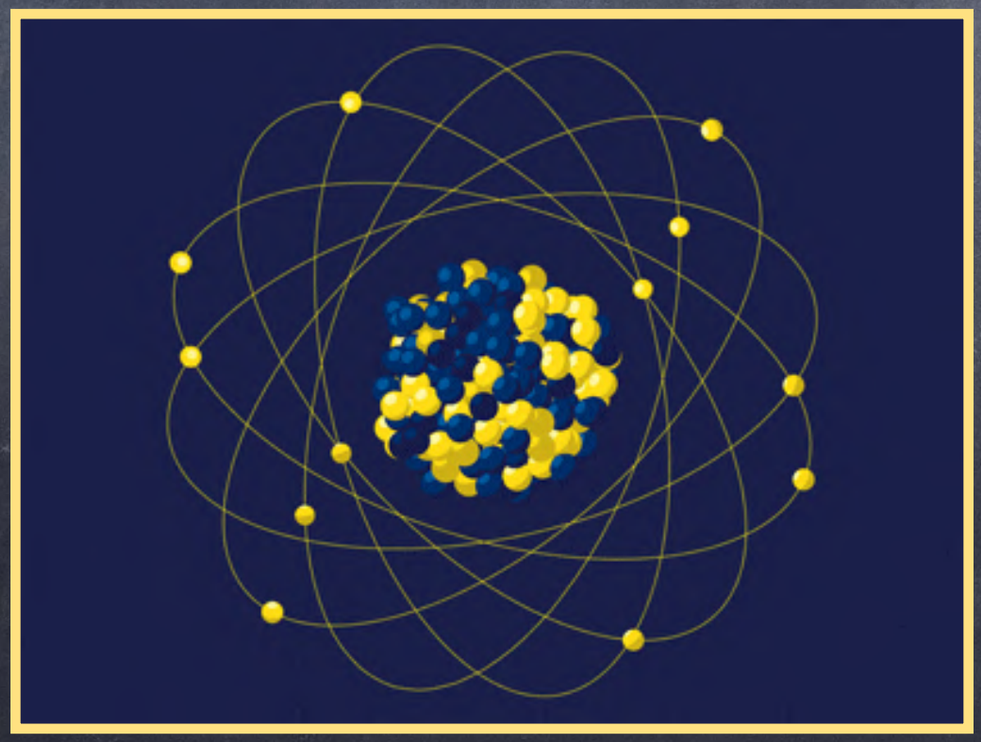
(400 a.C)

What is matter made of?

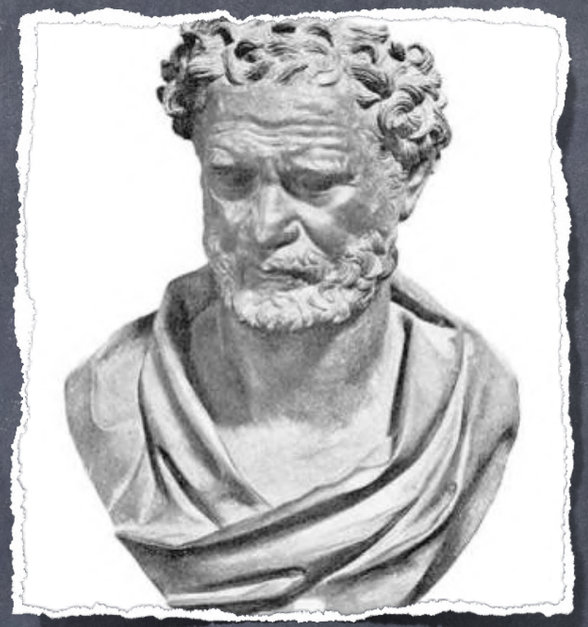


Democritus

(400 a.C)



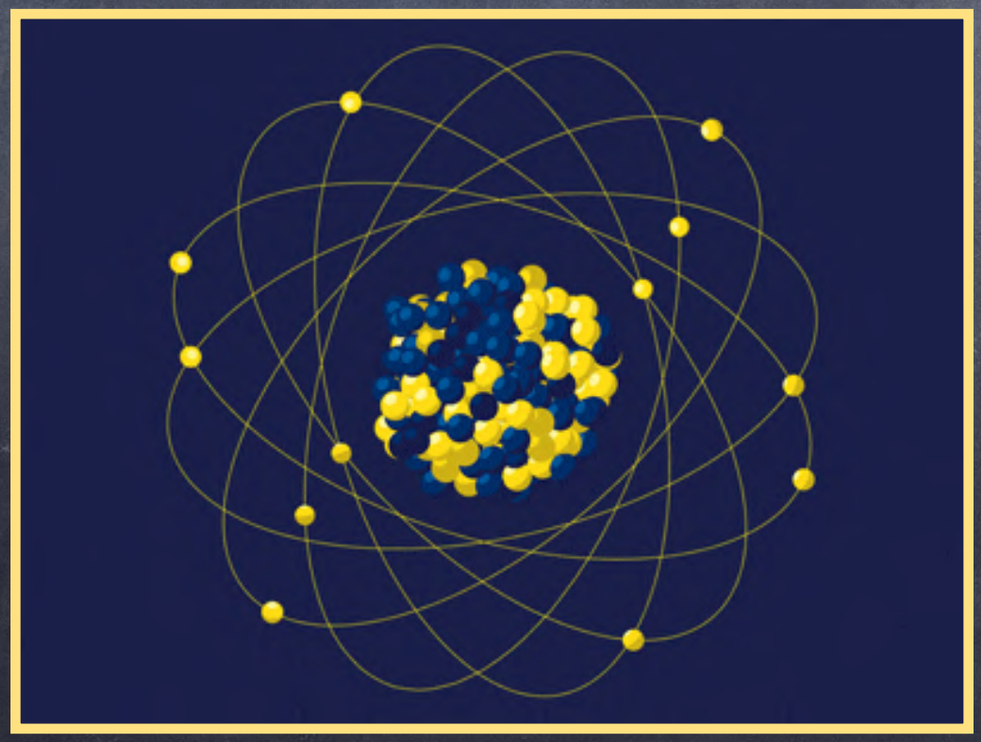
What is matter made of?



Democritus

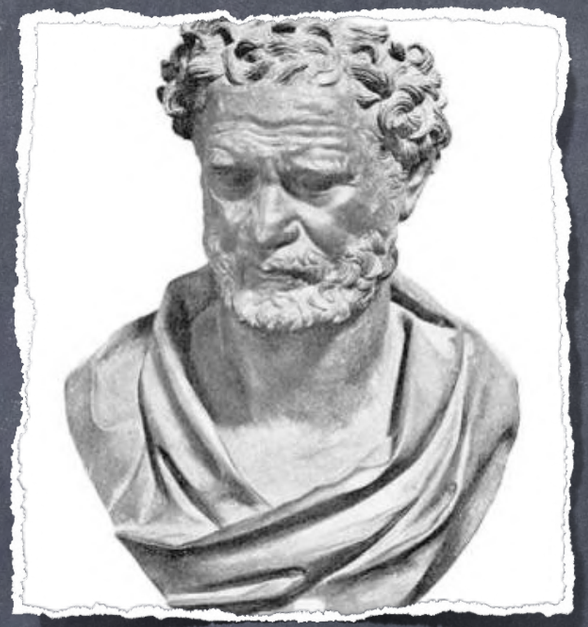
(400 a.C)

ατομο



ATOM

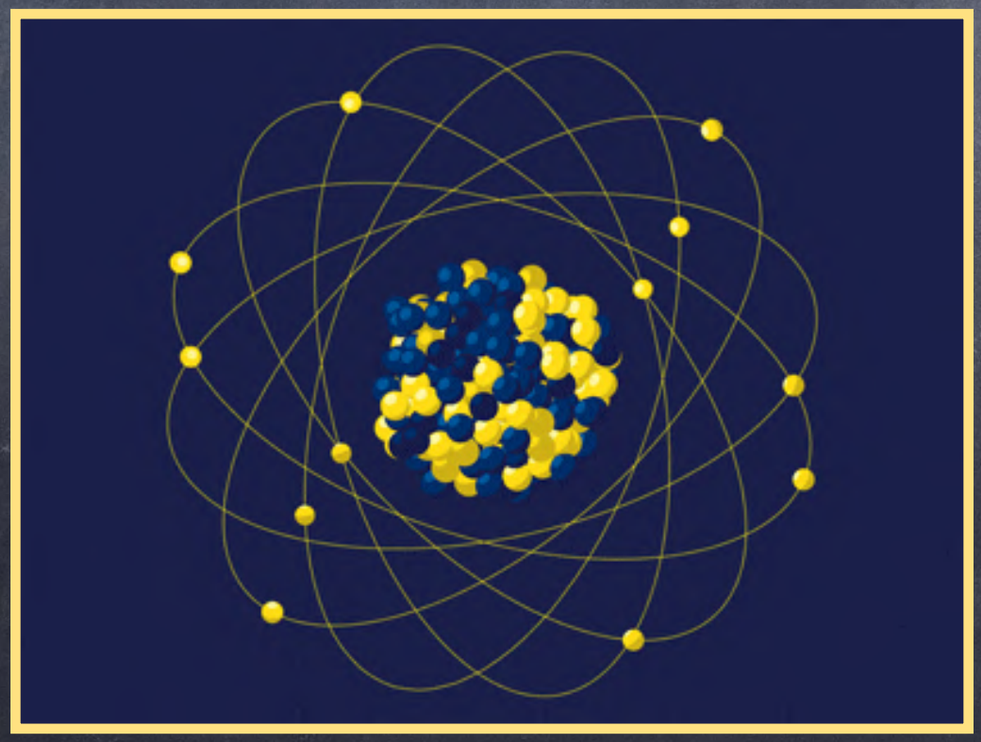
What is matter made of?



Democritus

(400 a.C)

$\alpha\tau o\mu o$

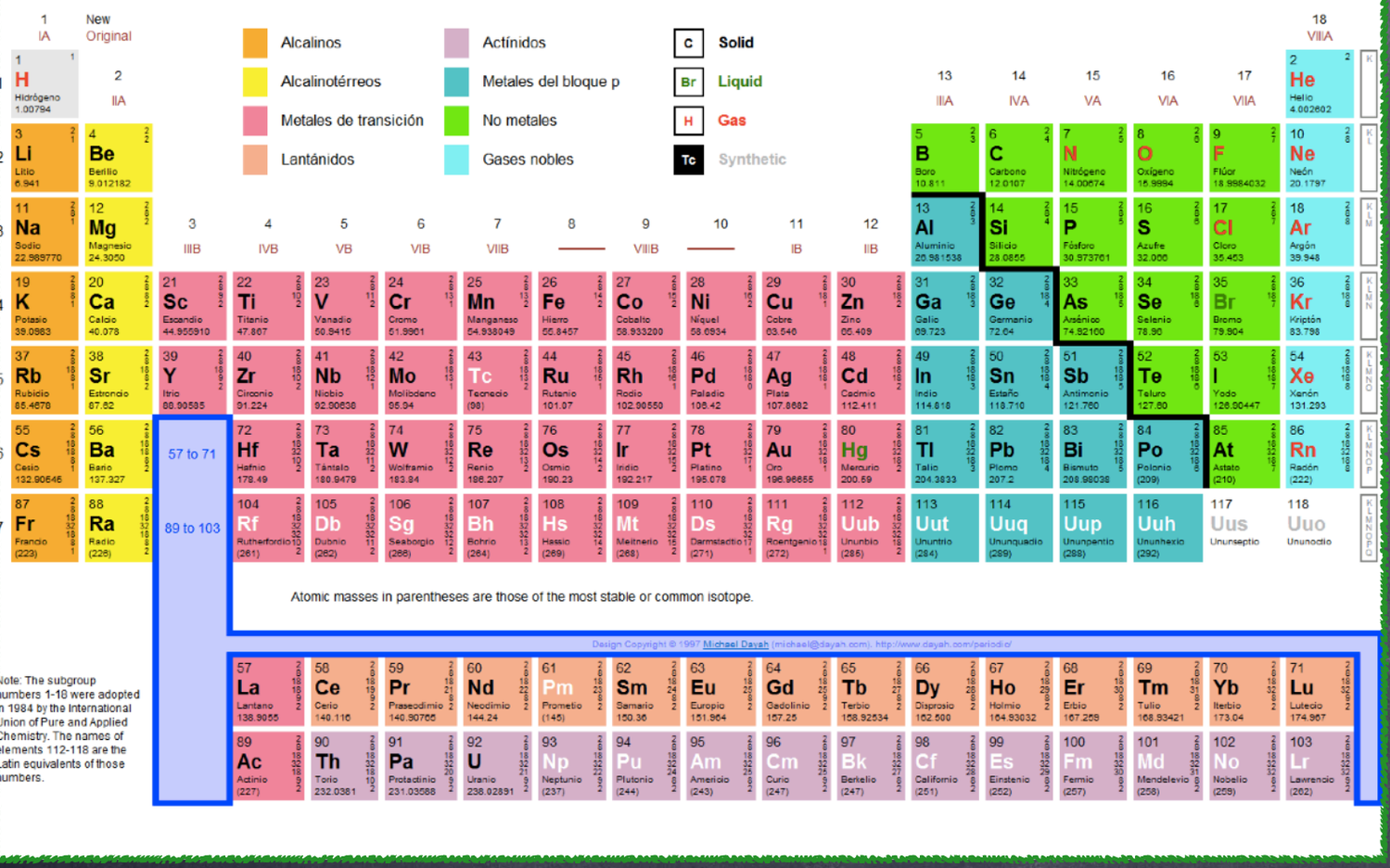


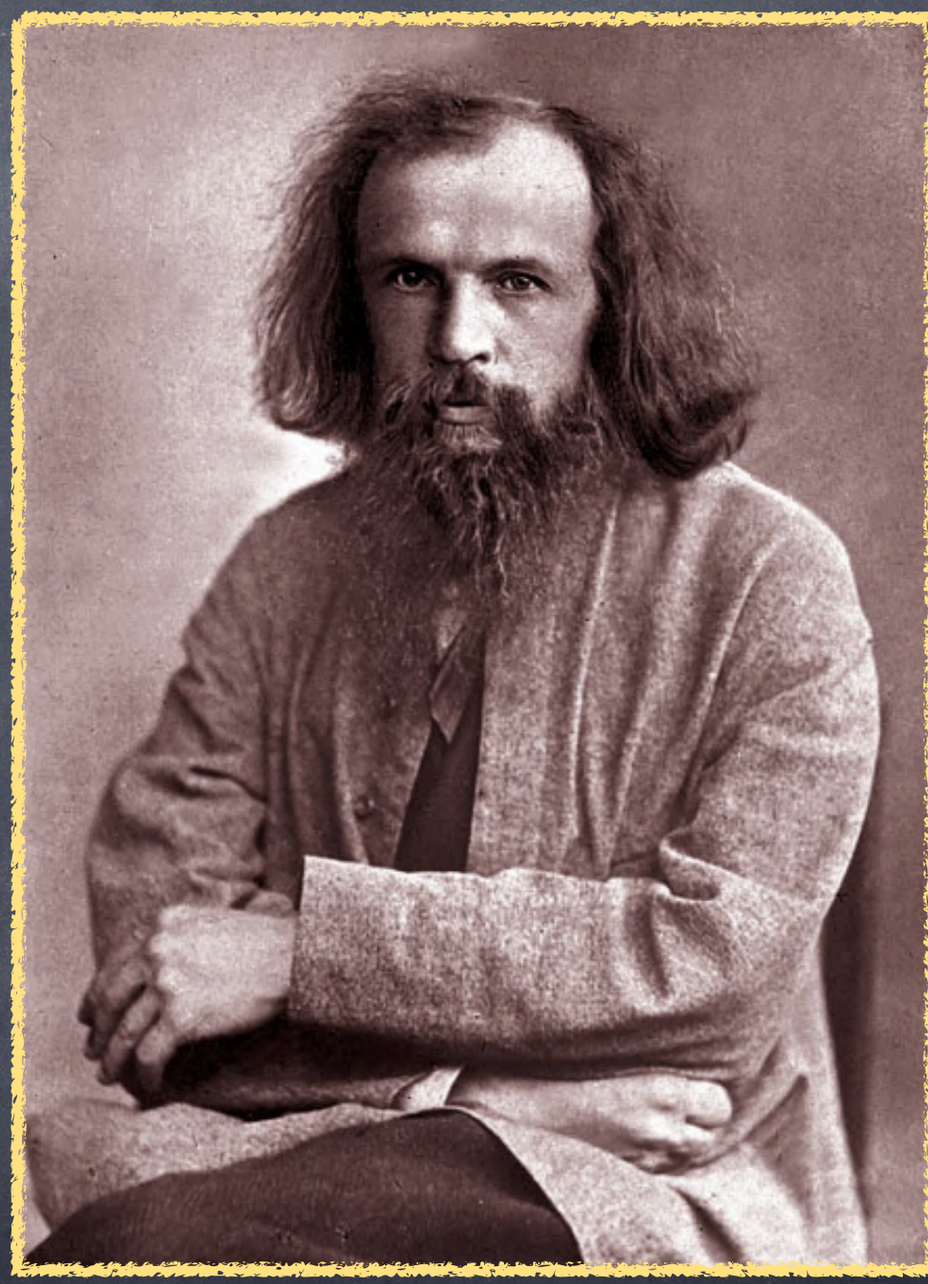
ATOM

α = without $\tau o\mu o$ = cut

What is matter made of?

Periodic table of the elements

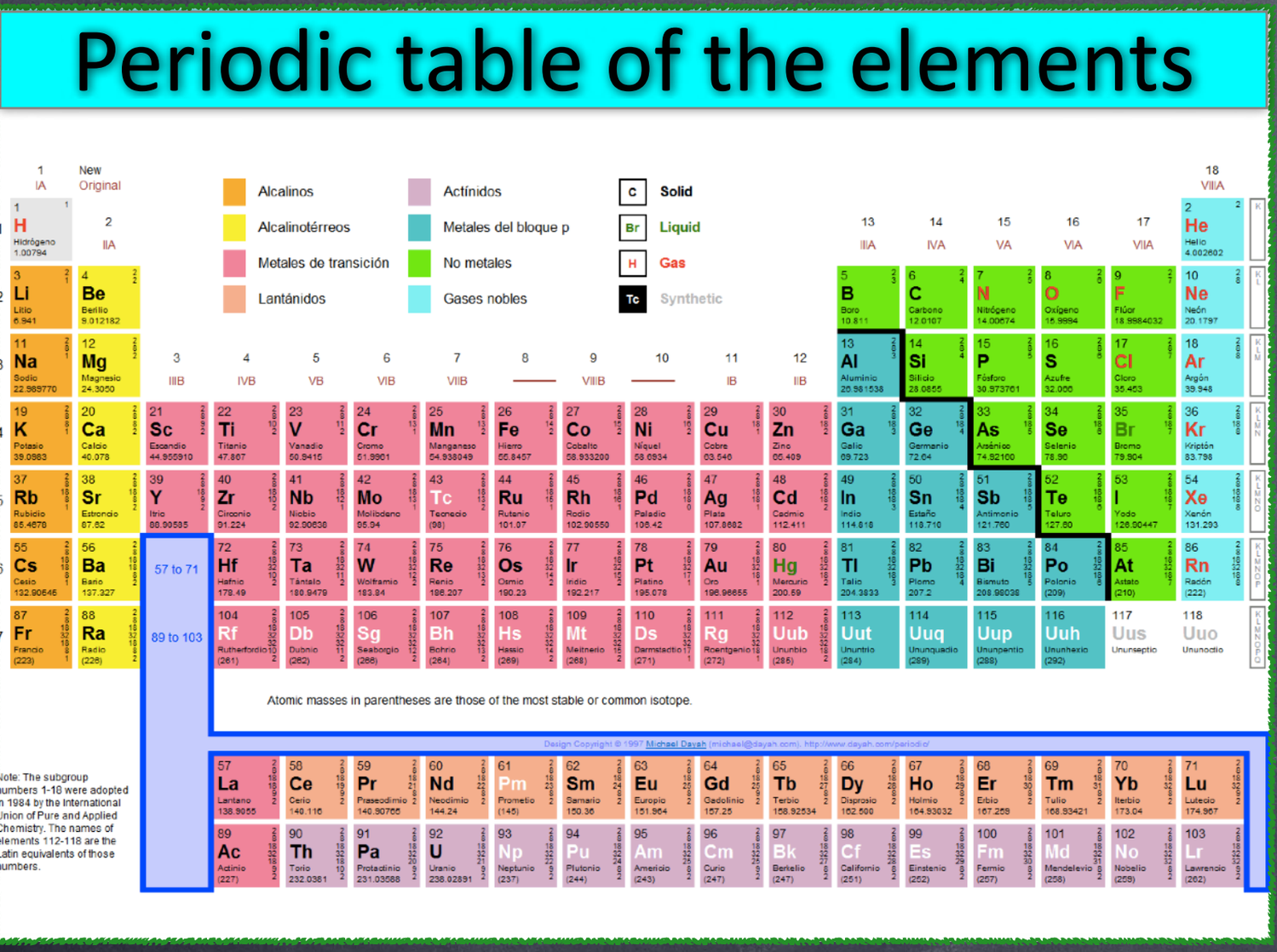


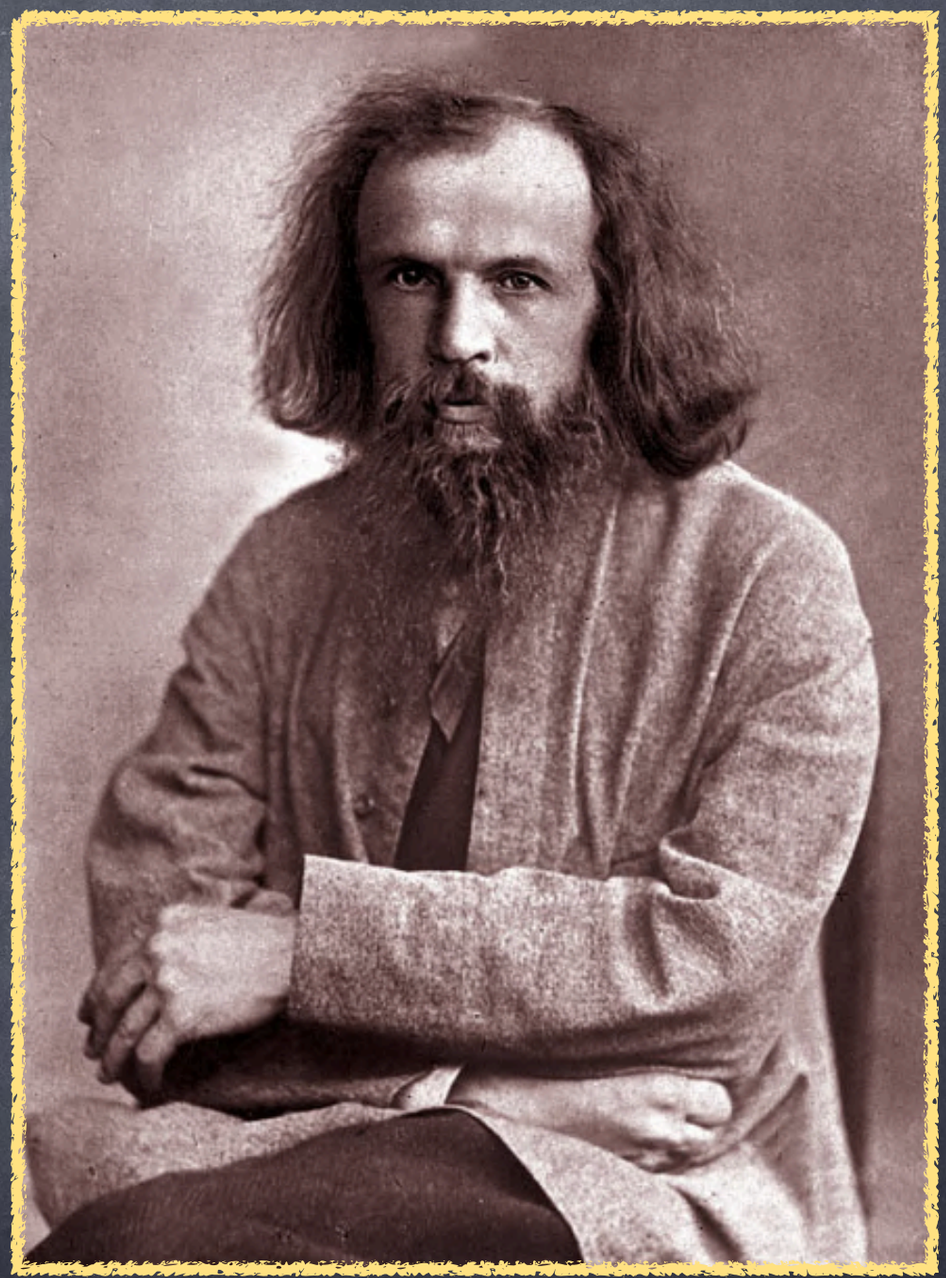


Dmitri Medeléyev (1869)

What is matter made of?

Periodic table of the elements



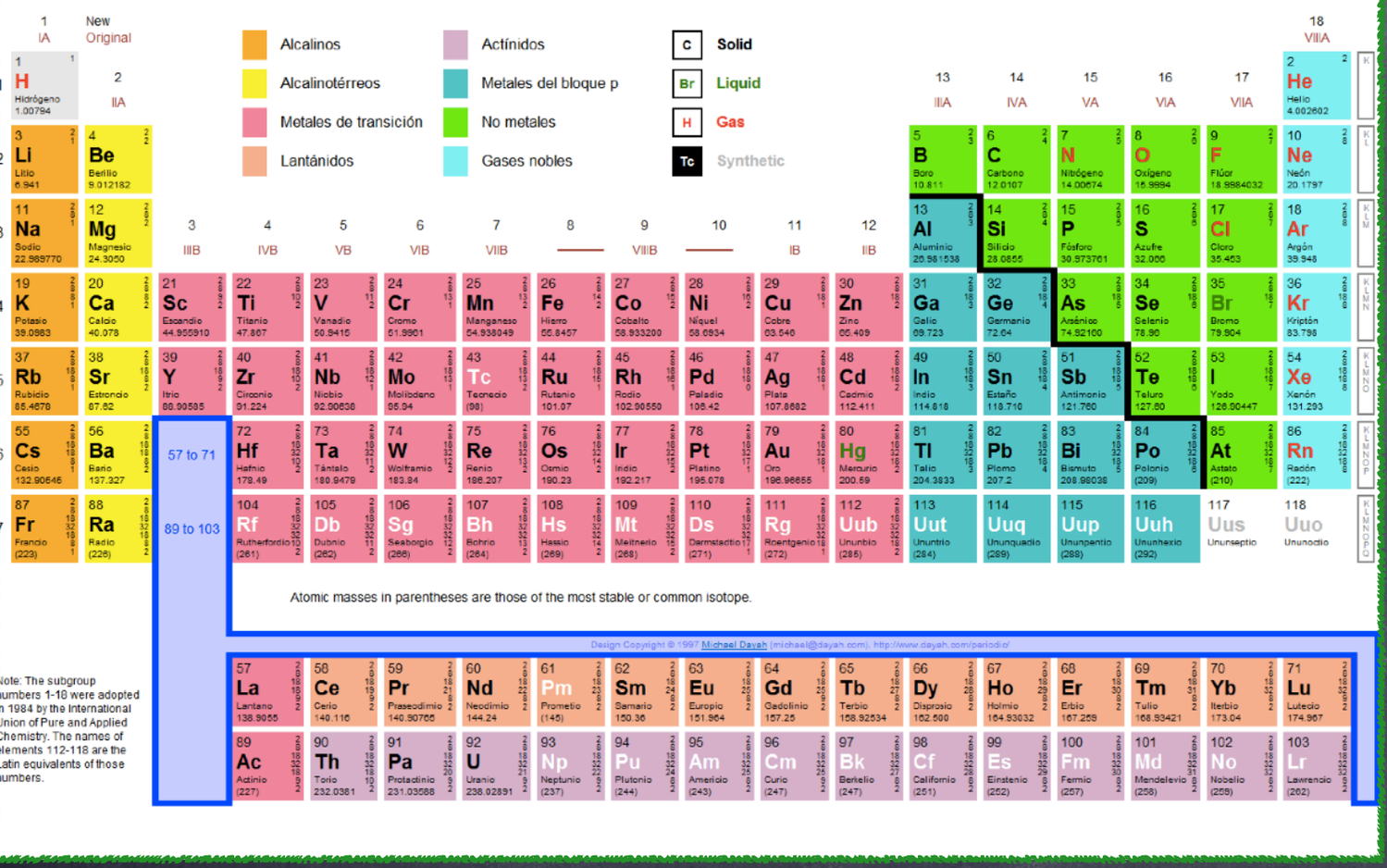


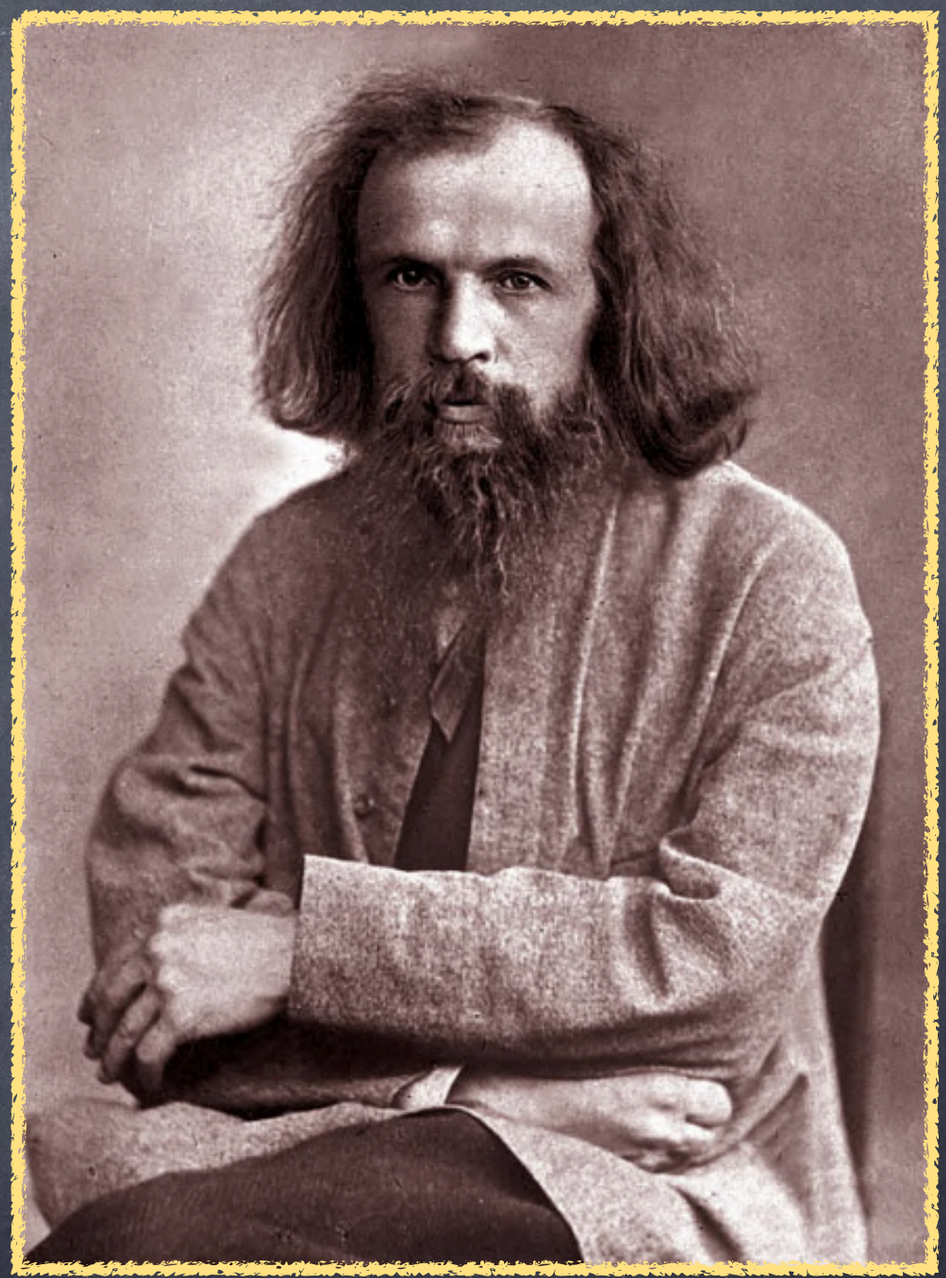
- Periodicity of properties
- Discovery of new elements

Dmitri Medeléyev (1869)

What is matter made of?

Periodic table of the elements



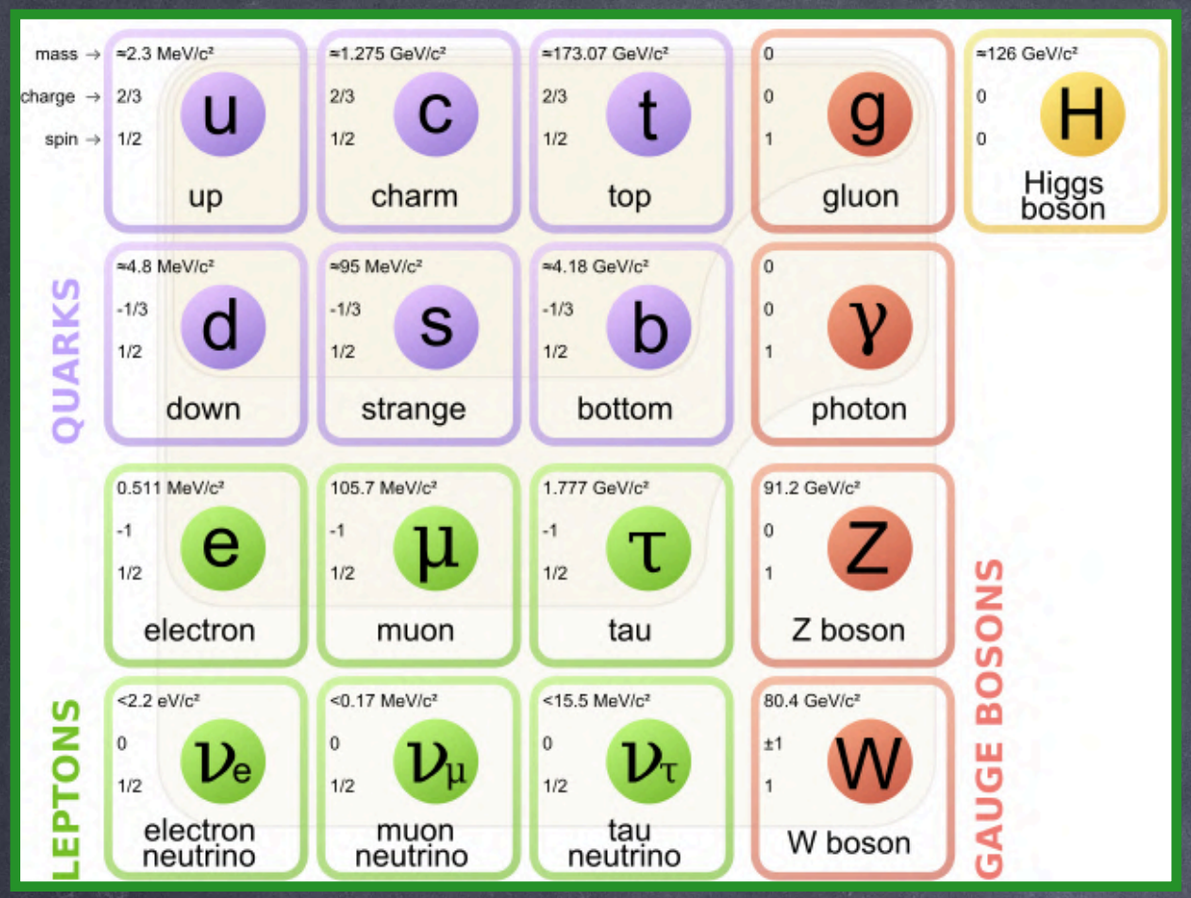


Dmitri Medeléyev (1869)

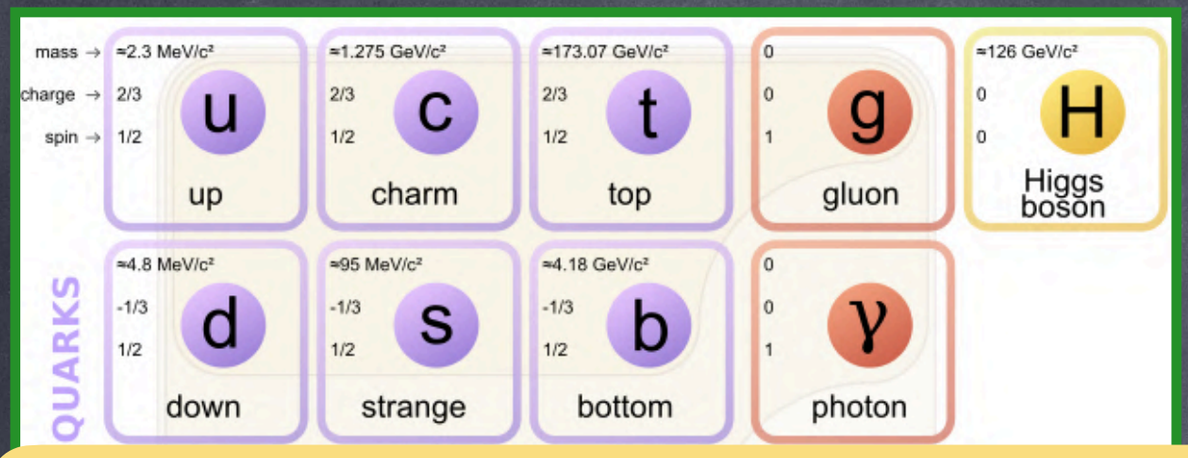
- Periodicity of properties
- Discovery of new elements

Atom = Protons + Neutrons + Electrons

What is matter made of?

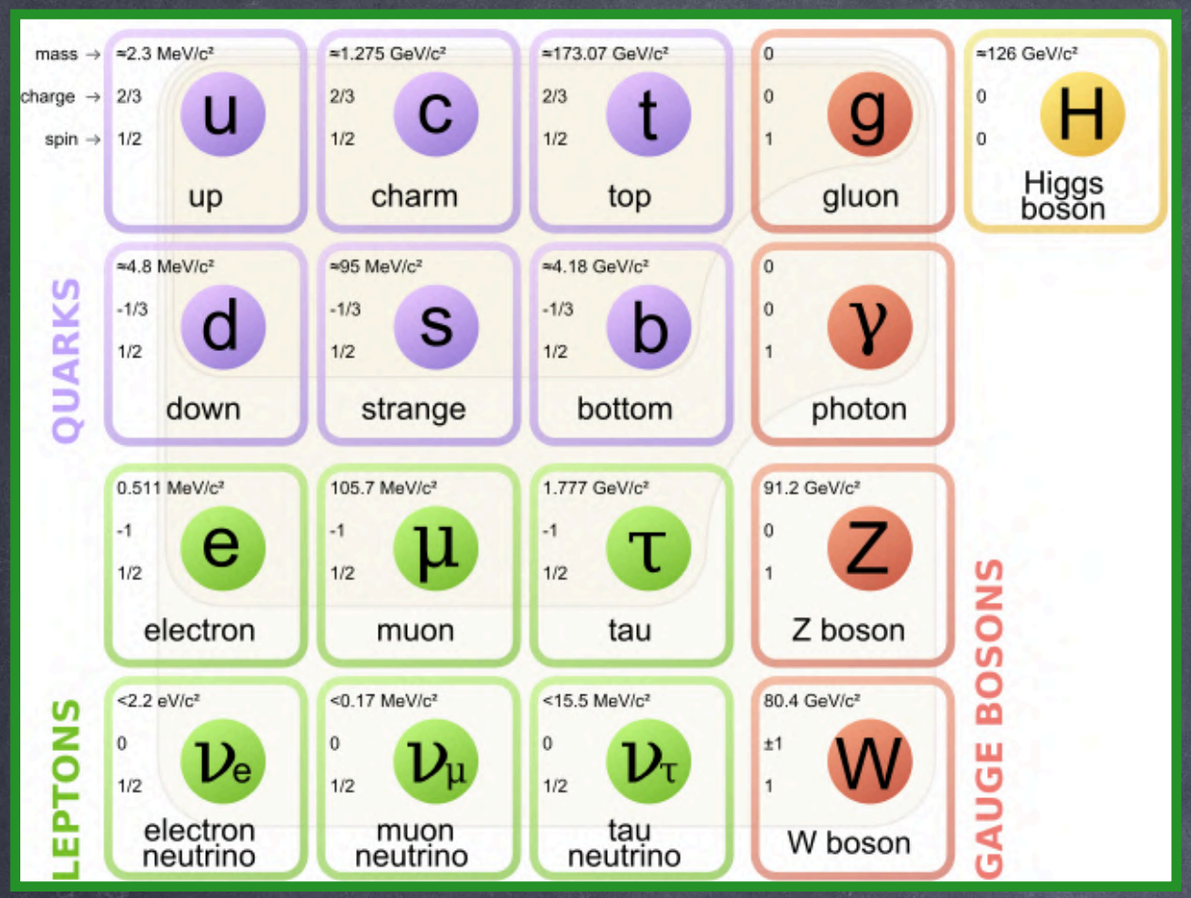


What is matter made of?

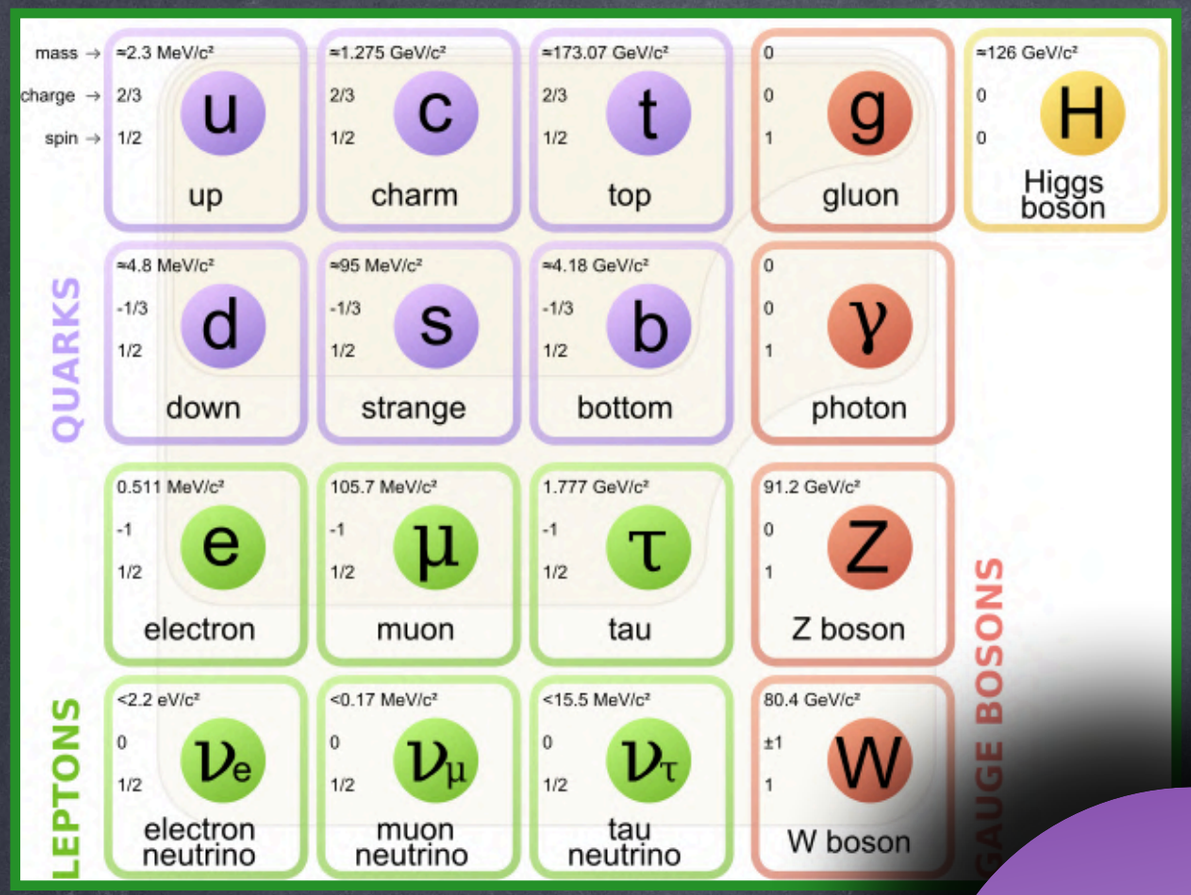


EXPERIMENT!!!

What is matter made of?



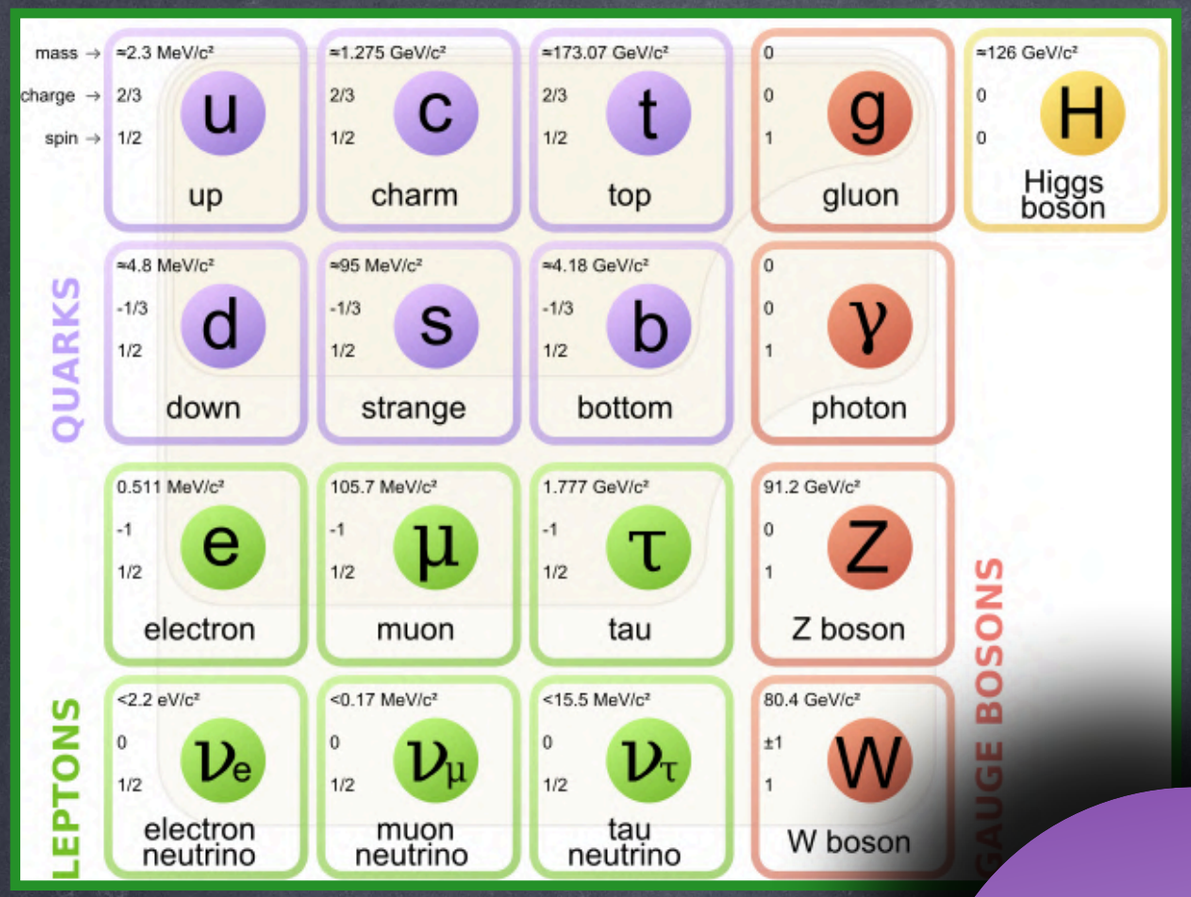
What is matter made of?



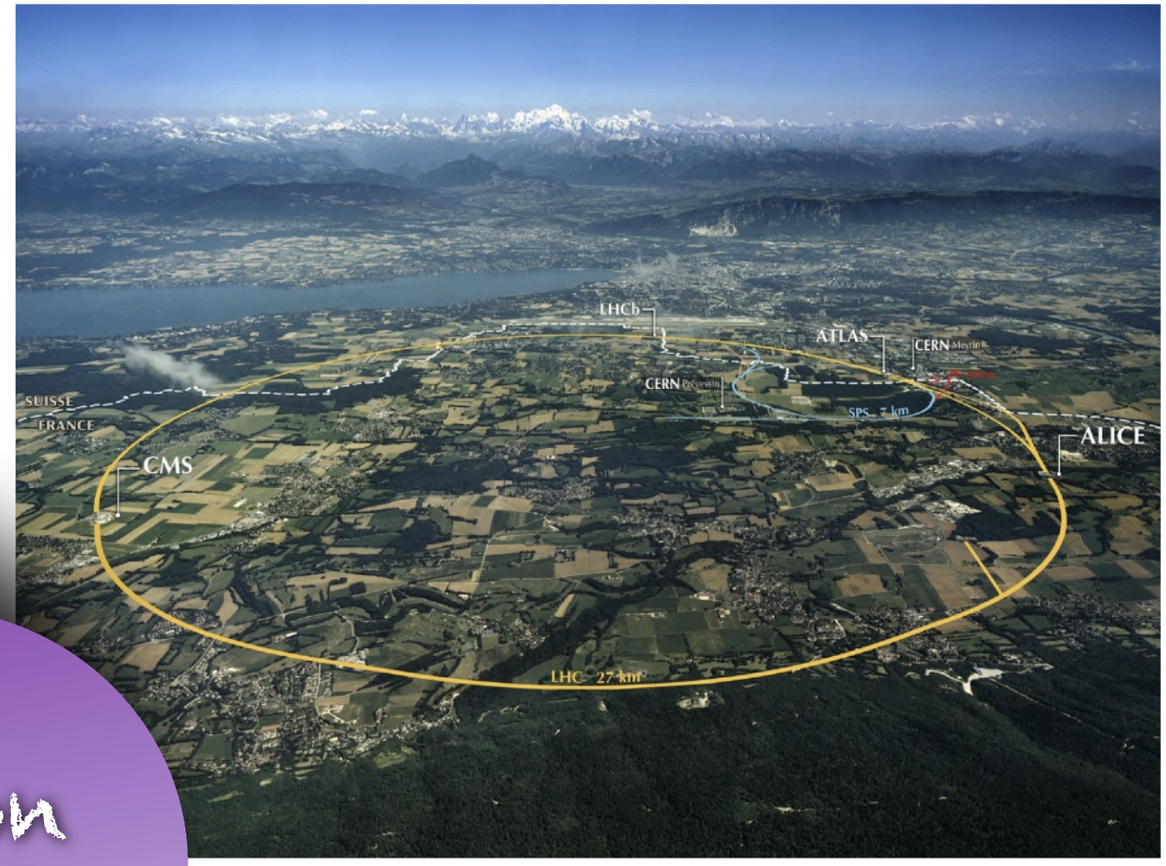
proton

$\sim 10^{-15}$ m

What is matter made of?



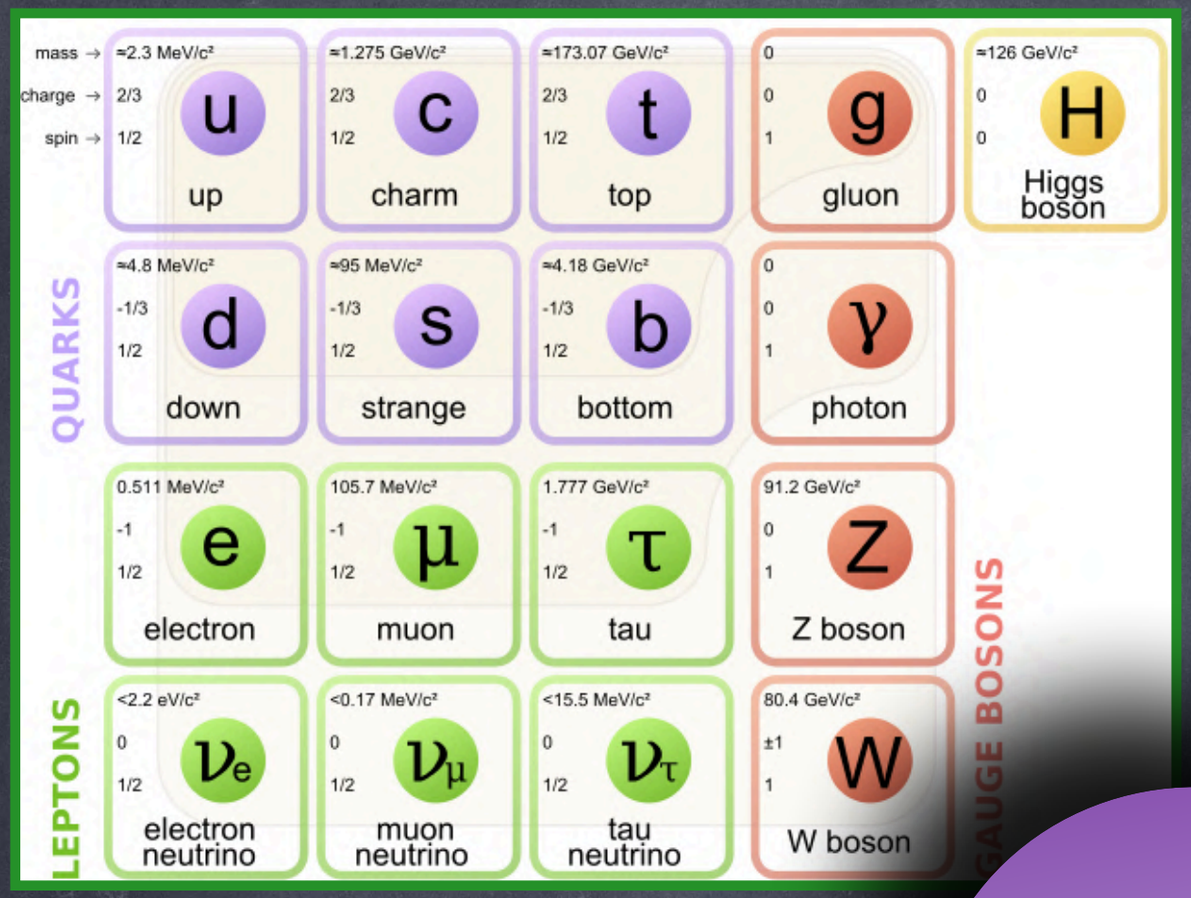
Large Hadron Collider (LHC)



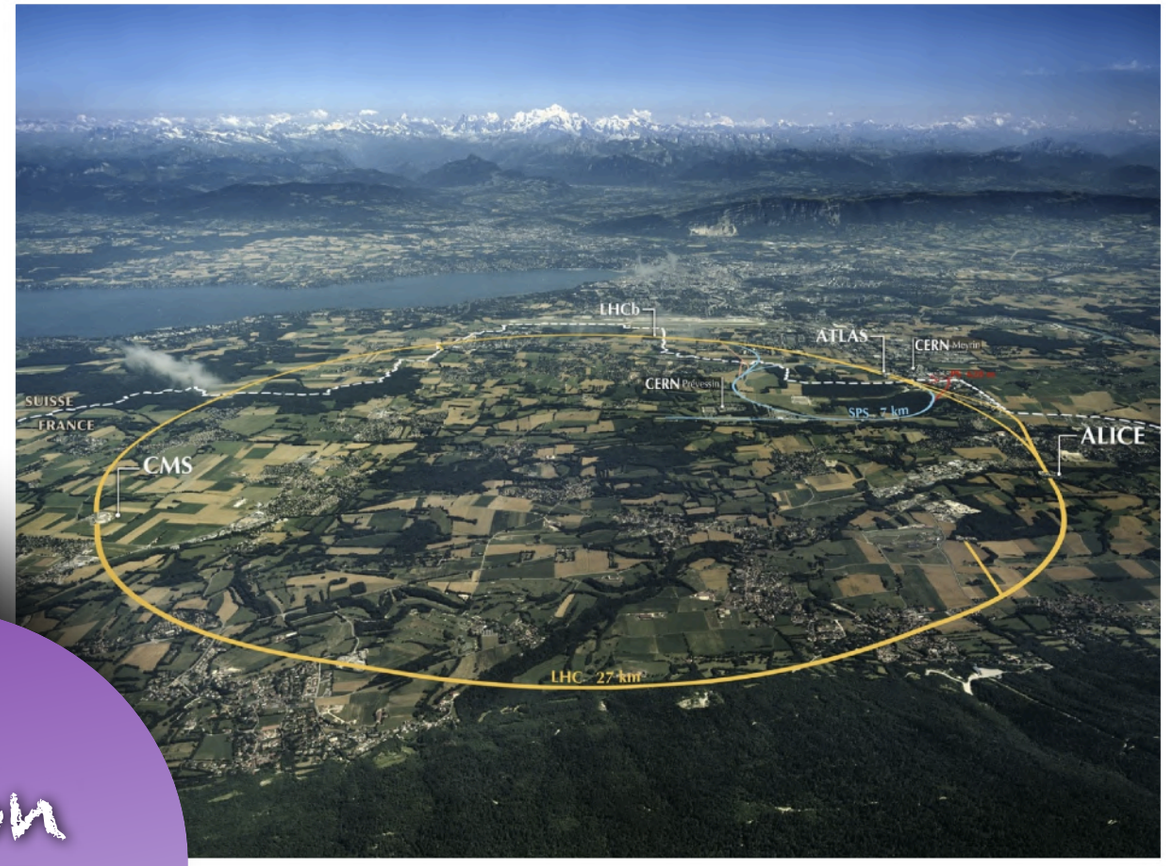
proton

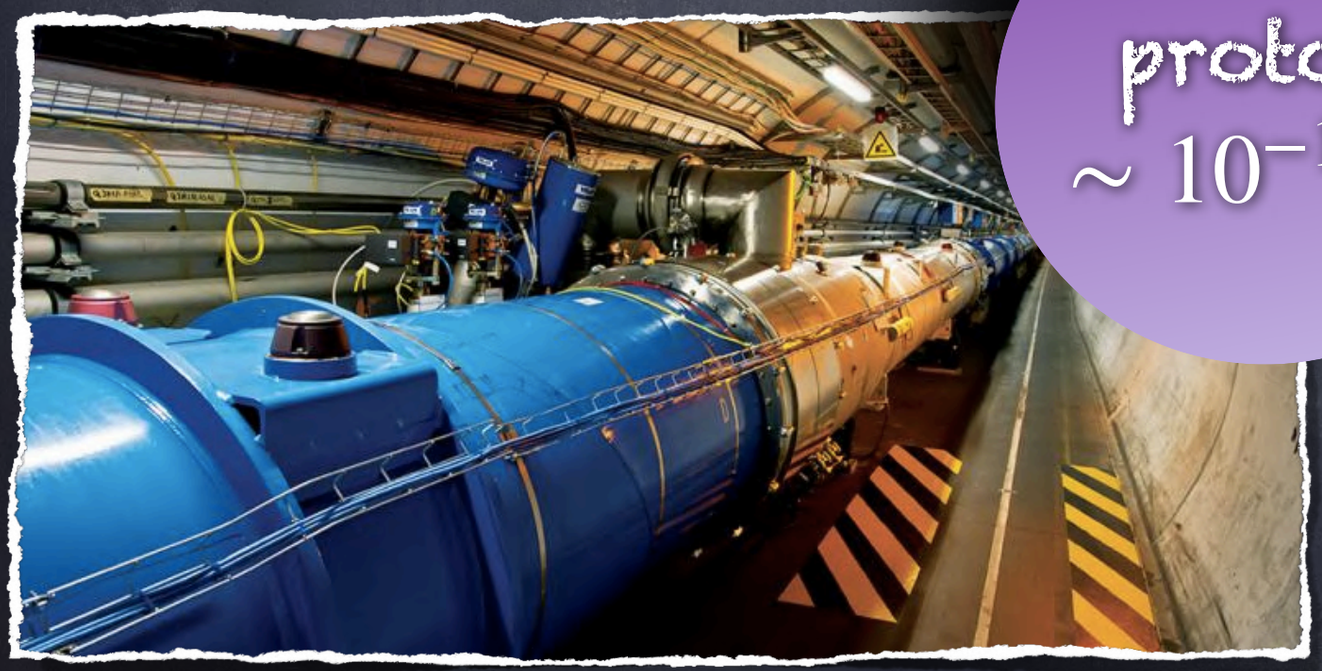
$\sim 10^{-15}$ m

What is matter made of?



Large Hadron Collider (LHC)

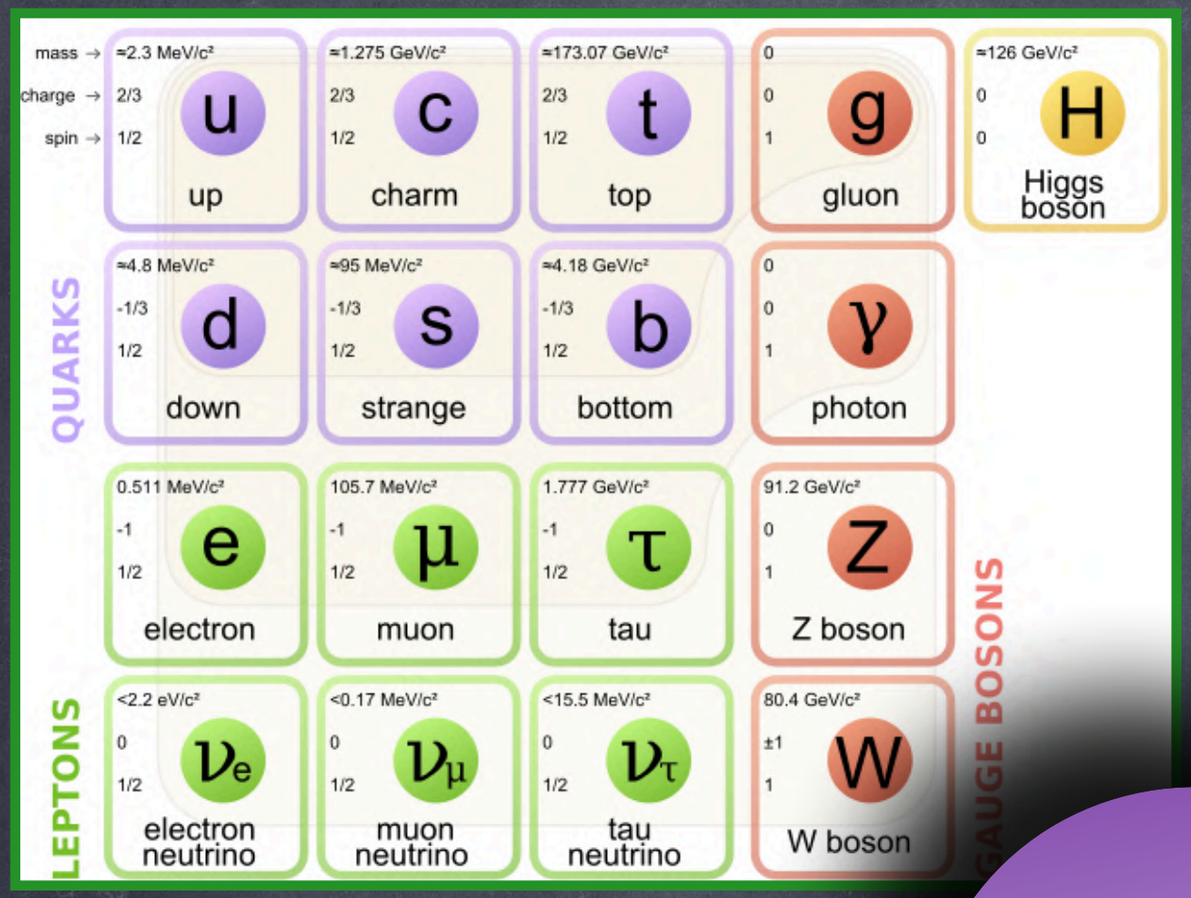




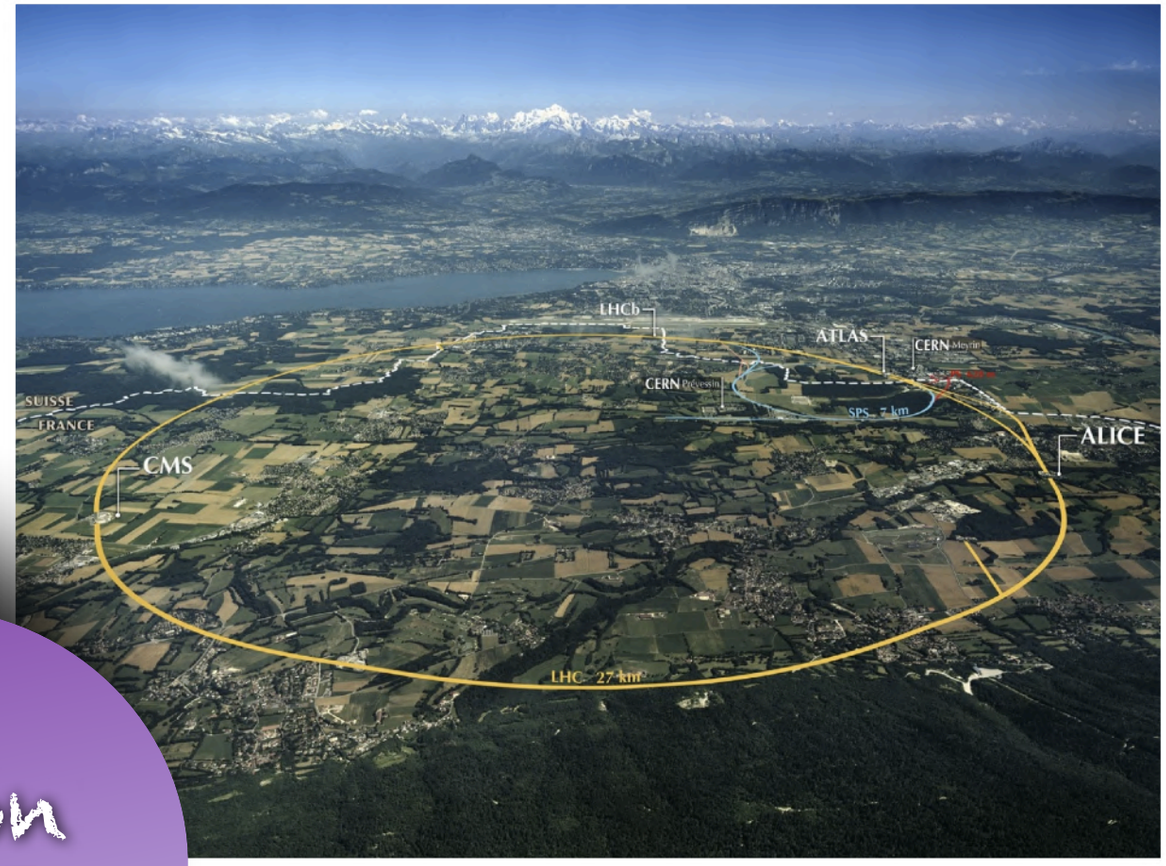
proton

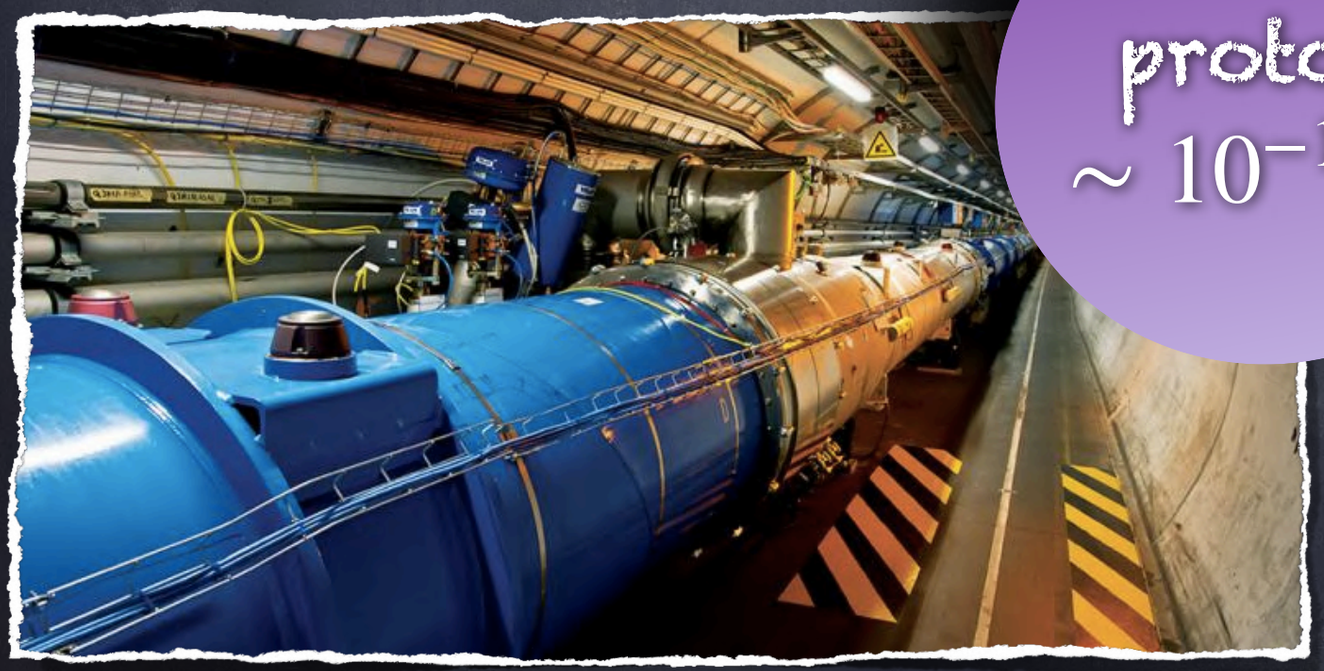
$\sim 10^{-15}$ m

What is matter made of?



Large Hadron Collider (LHC)

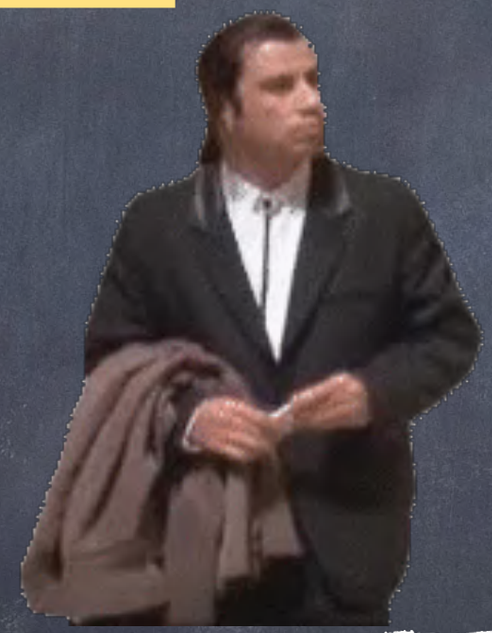


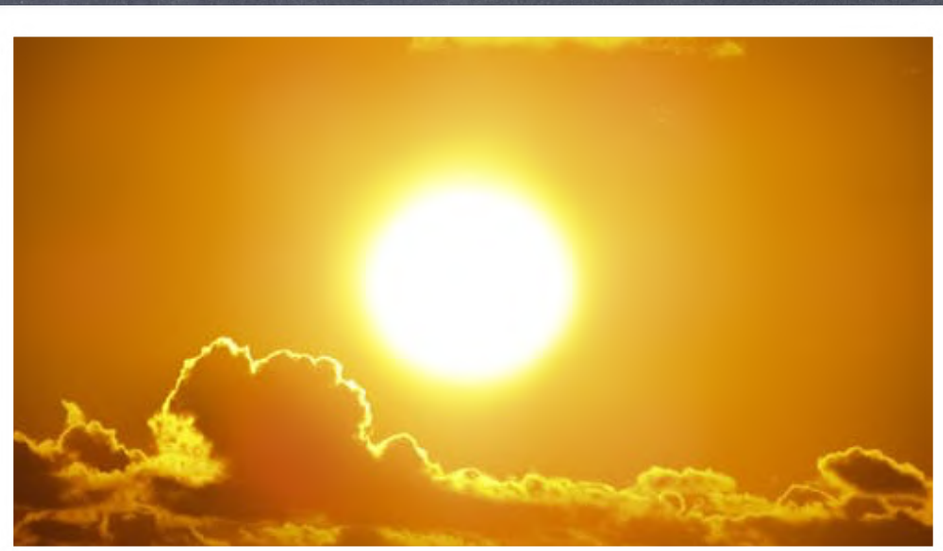


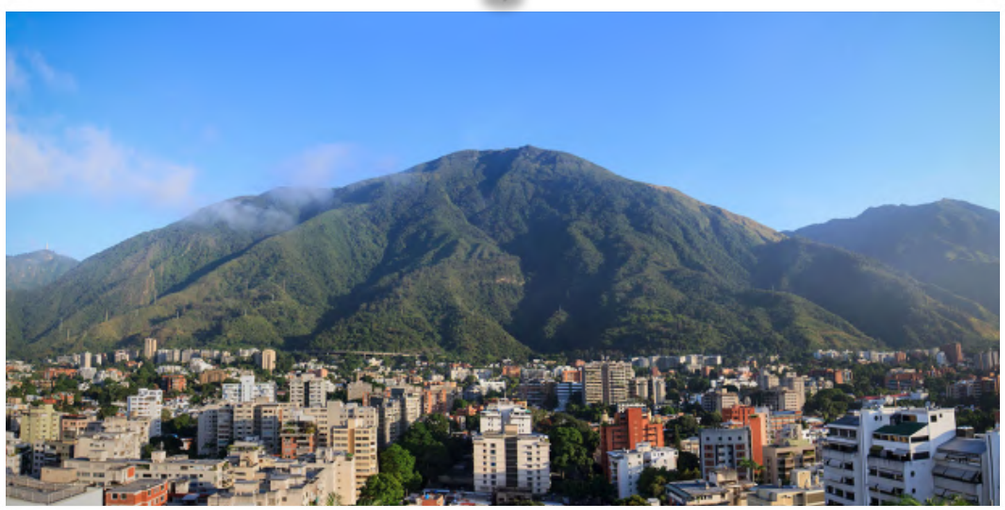
proton
$\sim 10^{-15}$ m

Evidence 1: the matter we know is made of atoms and subatomic particles

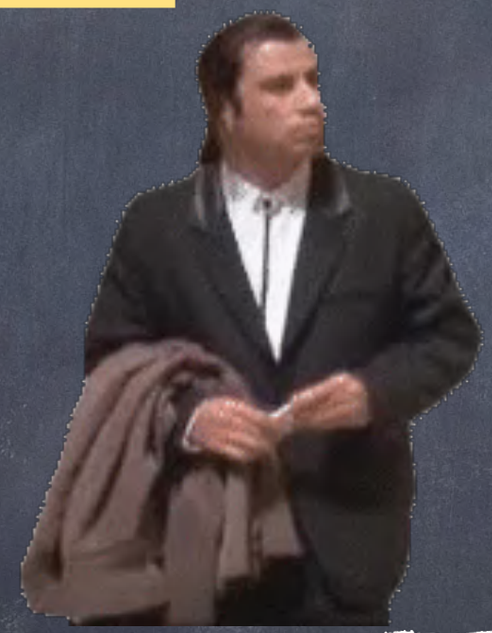
Where is the Dark Matter?

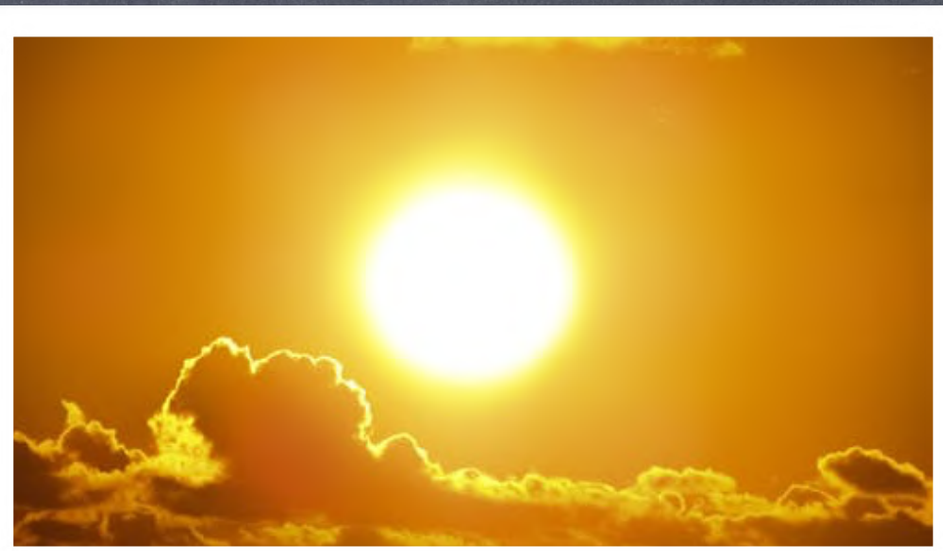


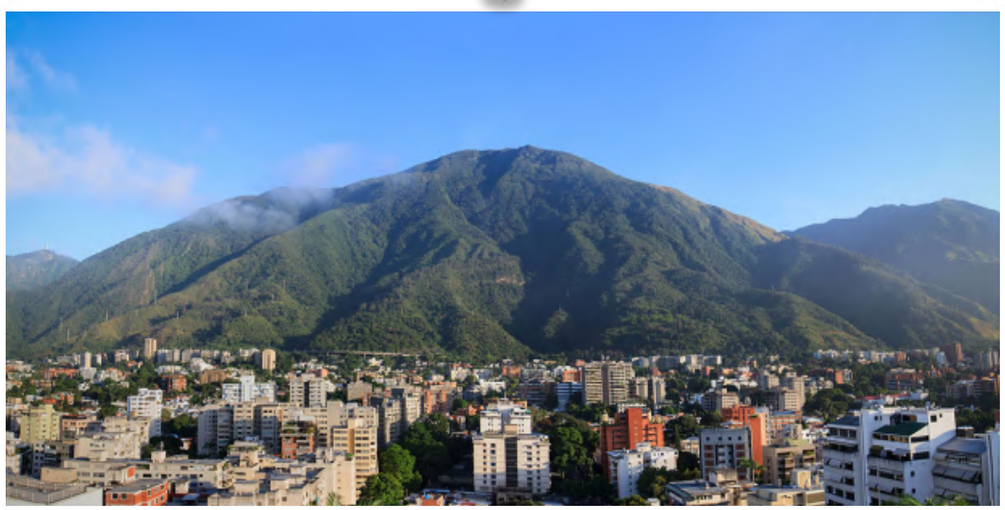




Where is the Dark Matter?





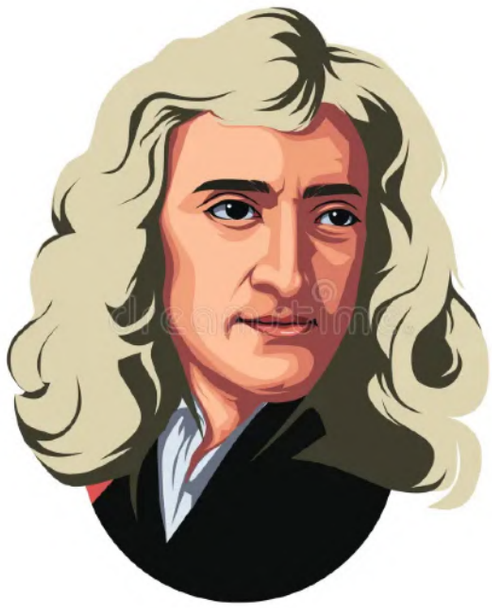


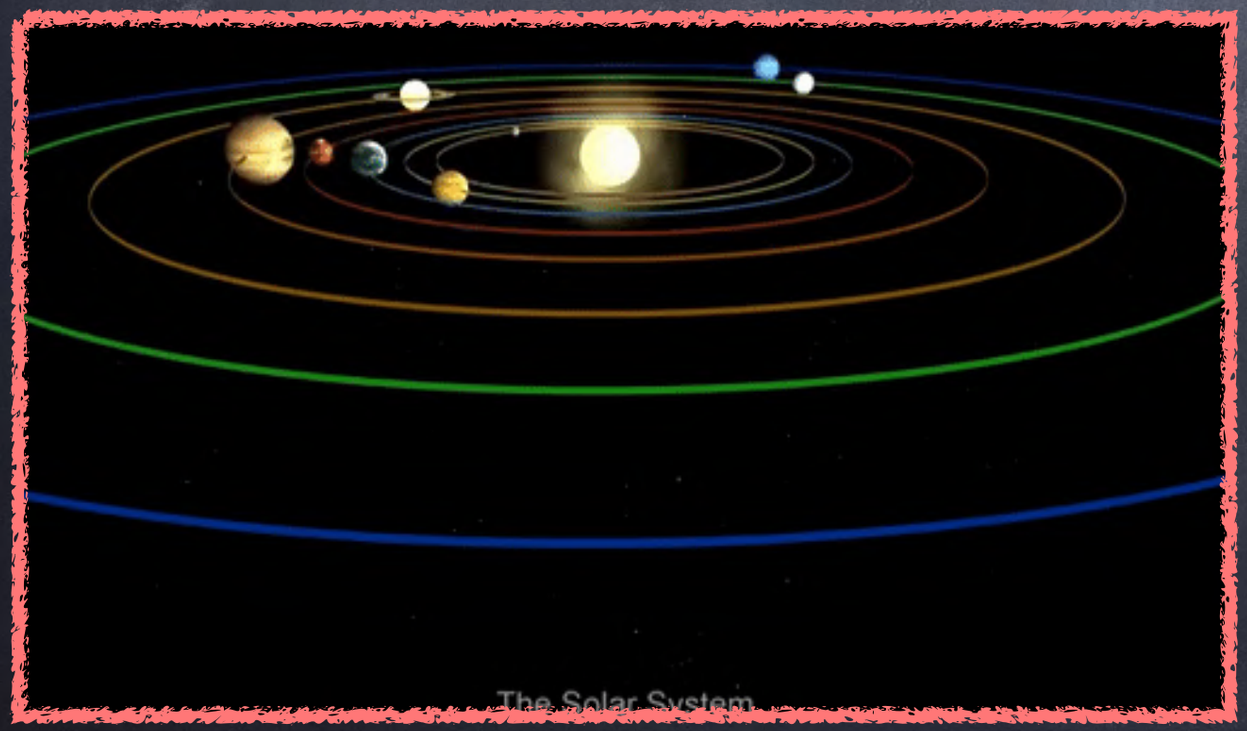
Where is the Dark Matter?

Act II: Gravity

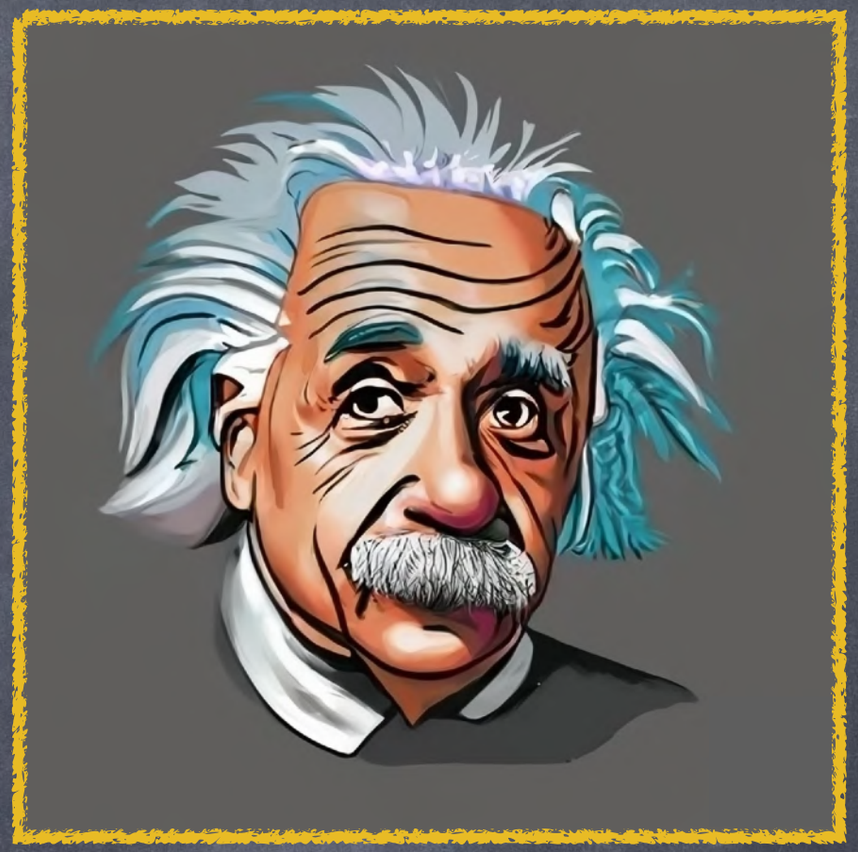
Act II: Gravity

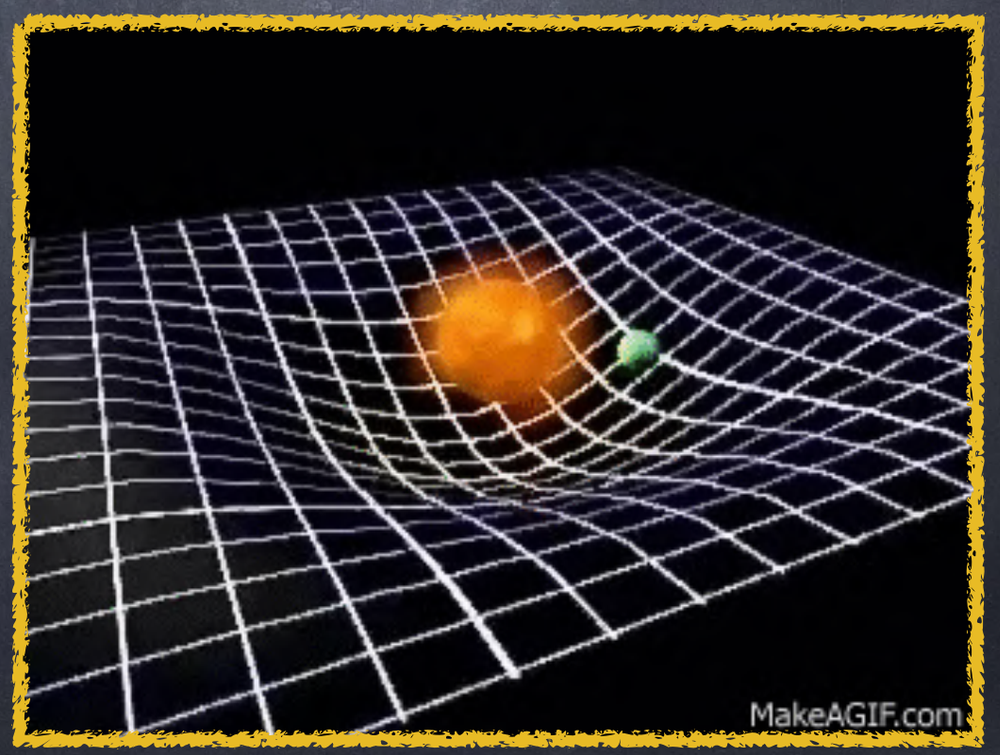
Isaac Newton (1667)



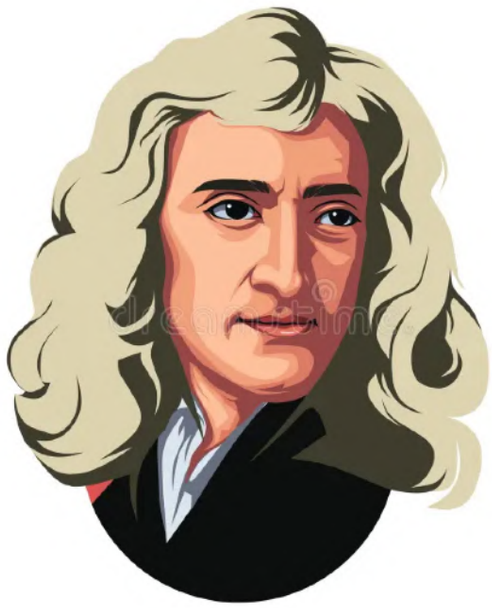


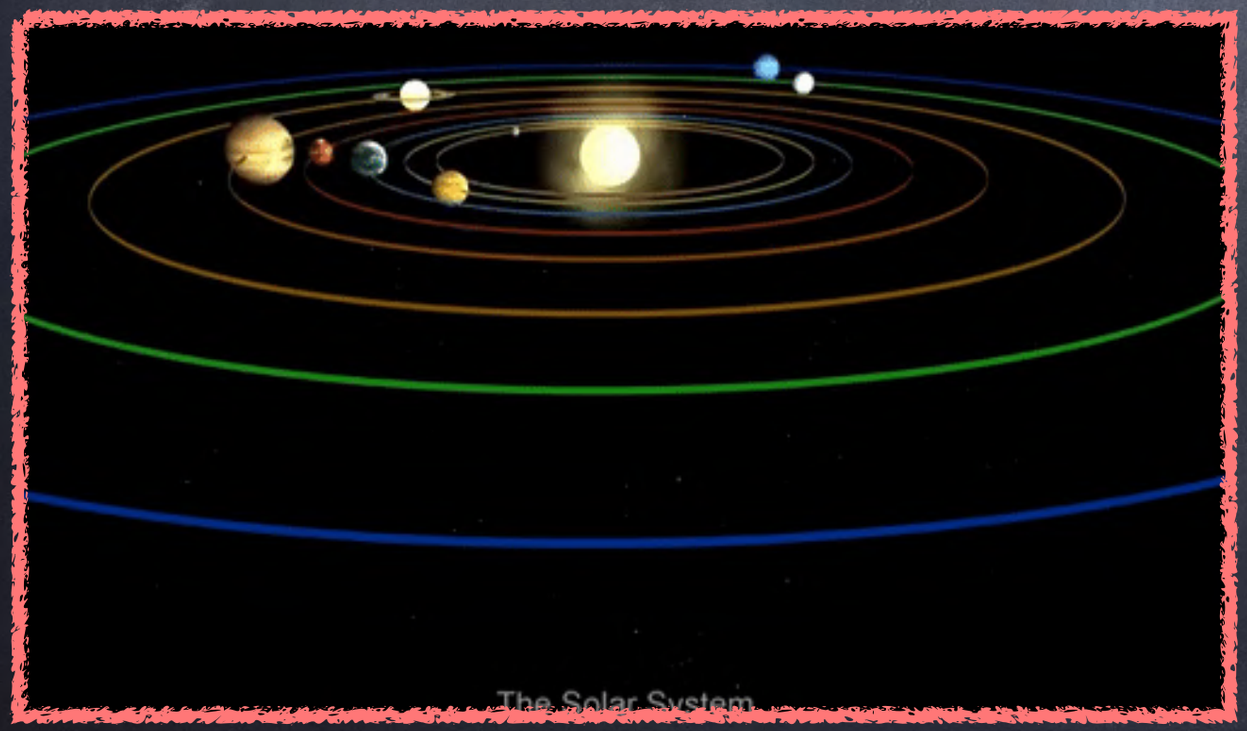
Albert Einstein (1915)



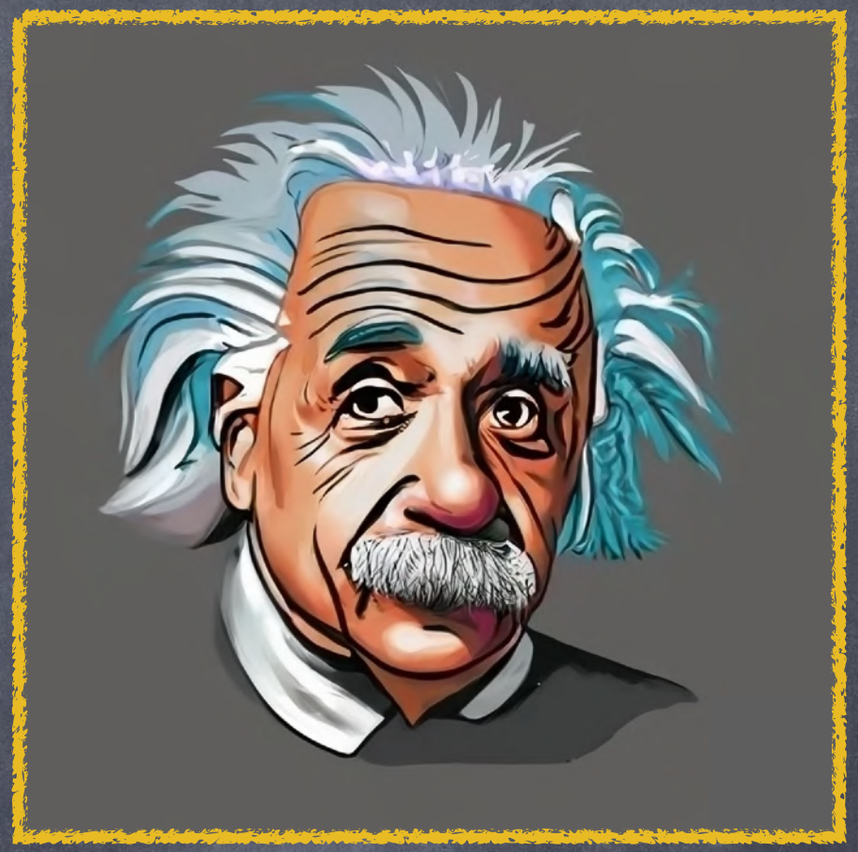


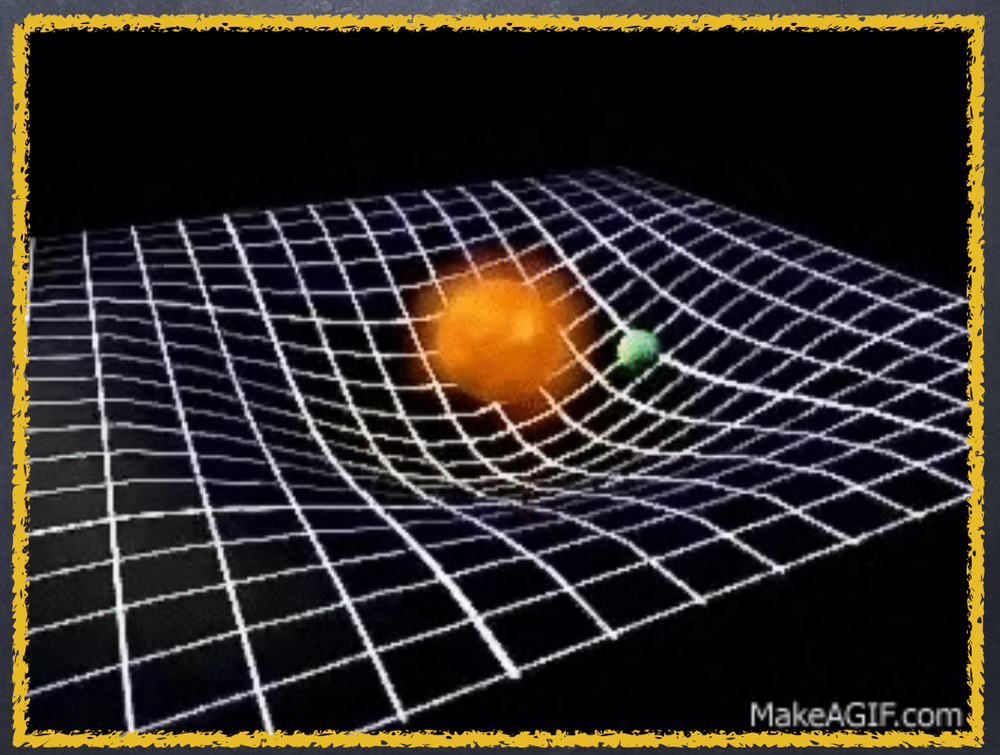
Isaac Newton (1667)





Albert Einstein (1915)





Gravity






Gravity

Gravity

Gravity

Gravity

$1.6\ m/s^2$

$9.8\ m/s^2$

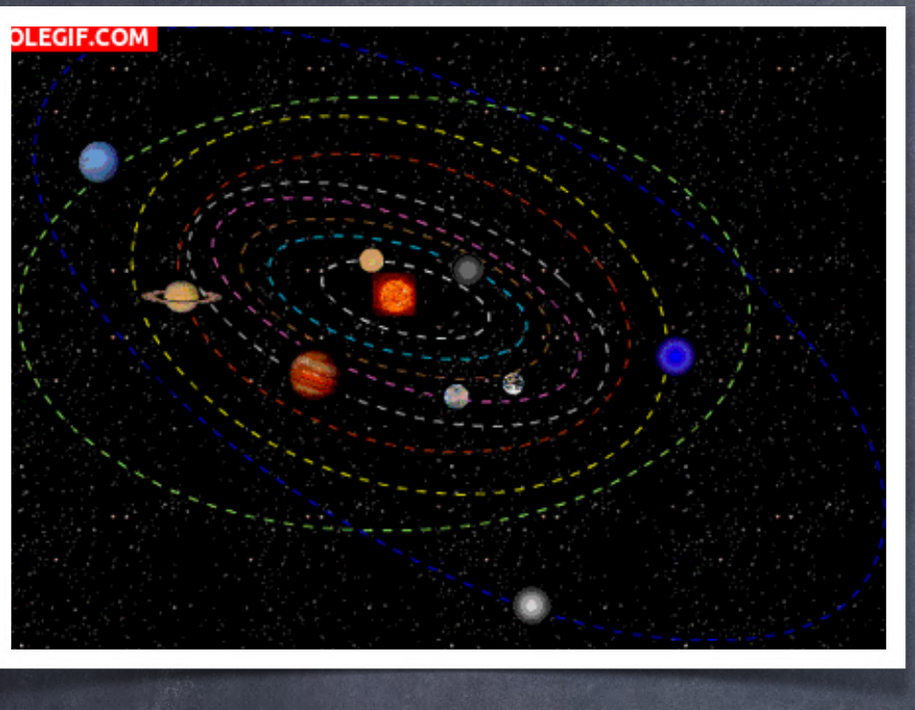
$274\ m/s^2$

Gravity

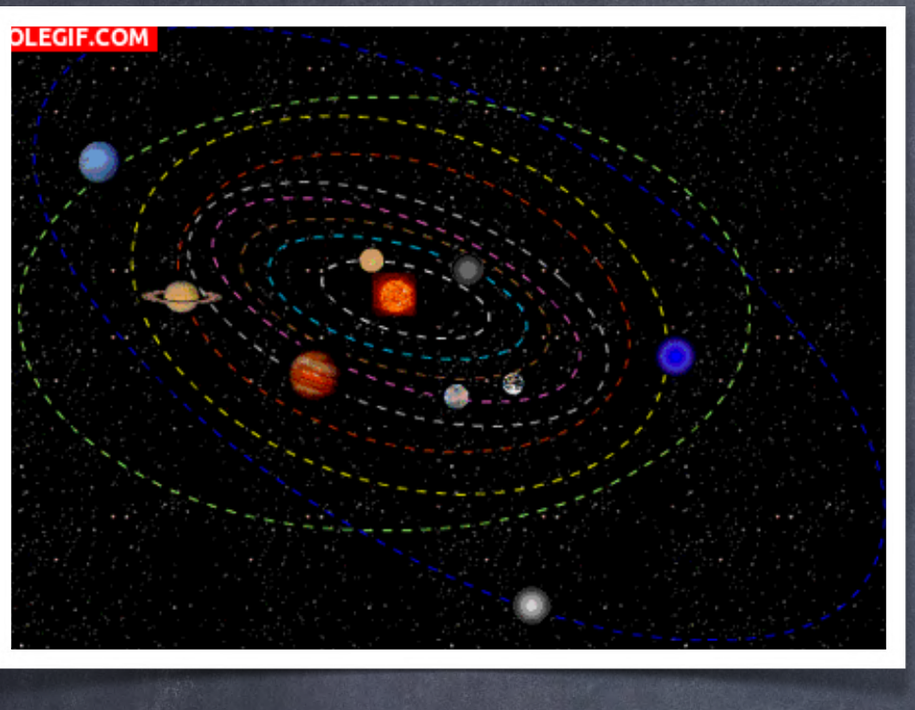
Evidence 2: the strength of gravity depends on the amount of matter generating it.

$1.6\ m/s^2$ $9.8\ m/s^2$ $274\ m/s^2$

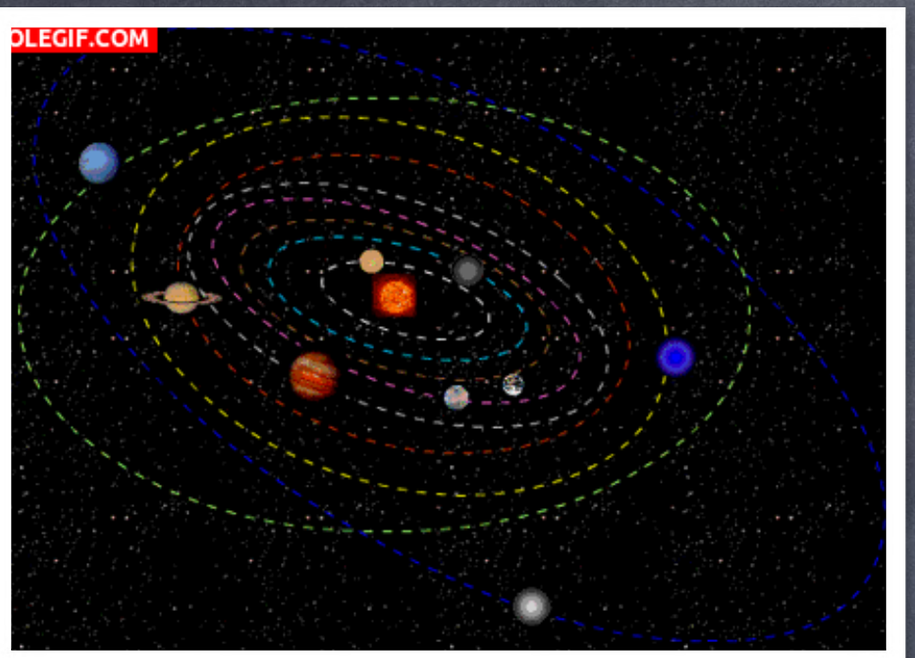
Gravity



Gravity

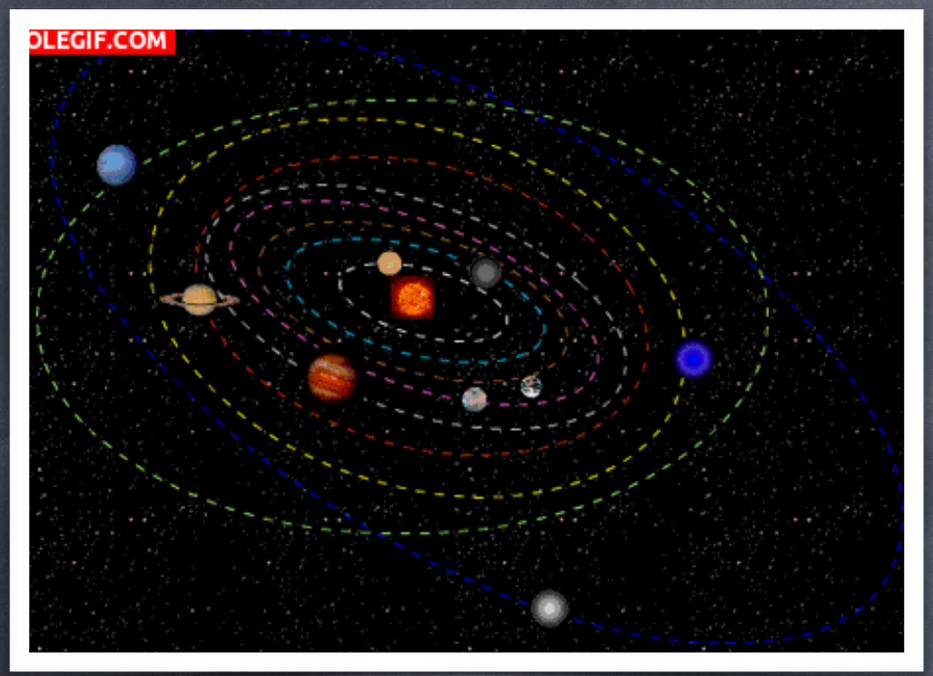


Gravity

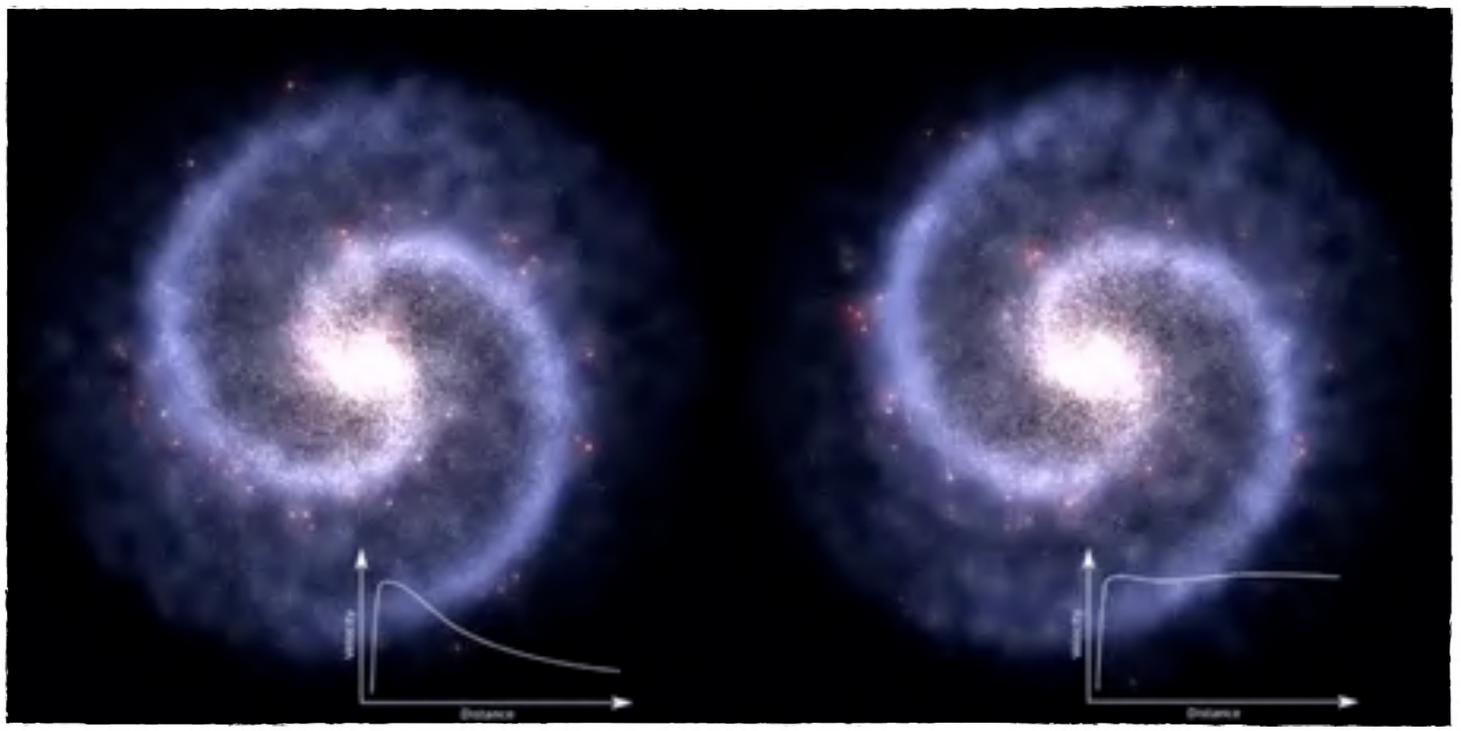


Evidence 3: Objects fall faster the closer they are to the matter generating gravity

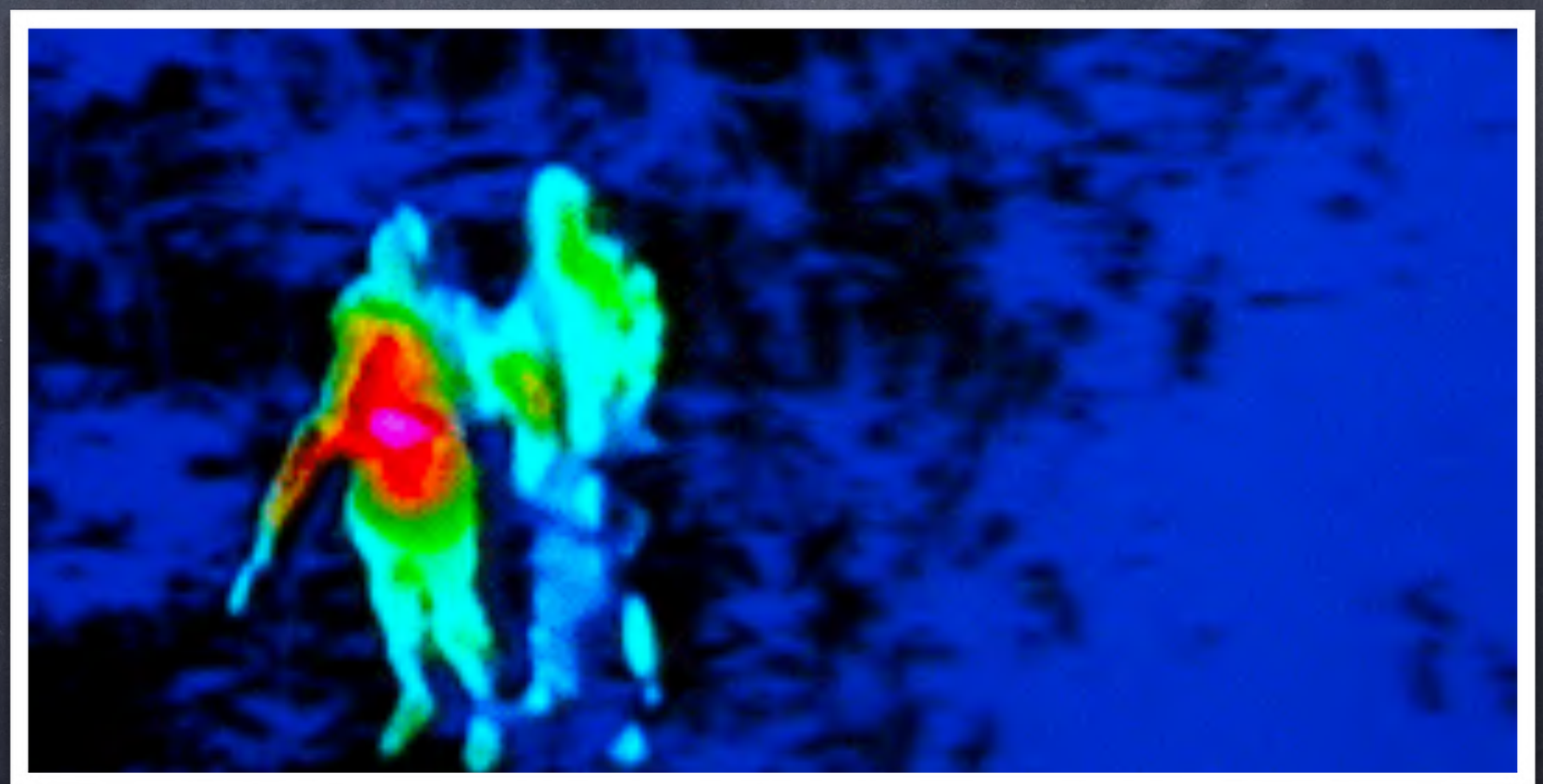
Gravity



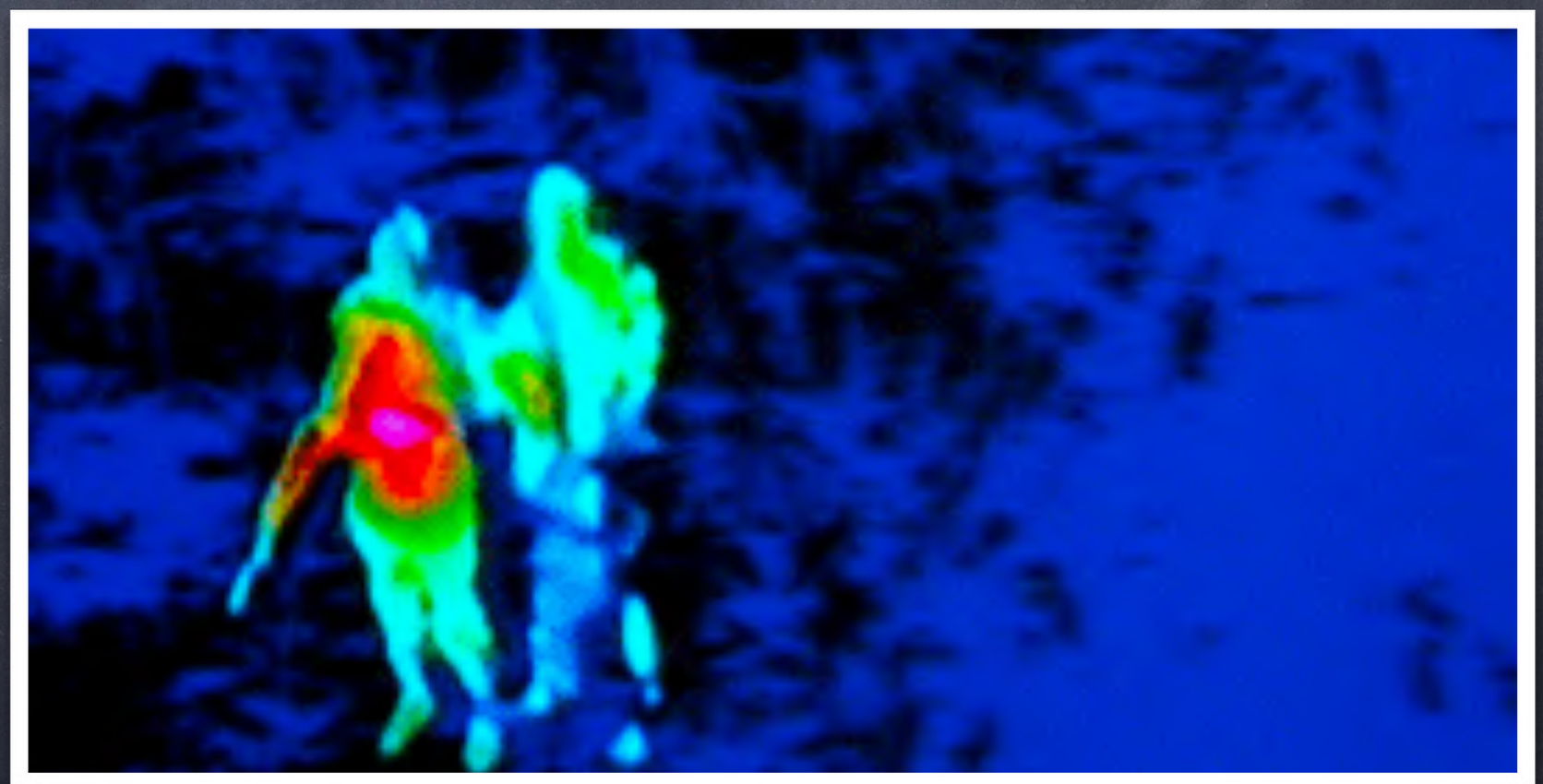
Evidence 3: Objects fall faster the closer they are to the matter generating gravity



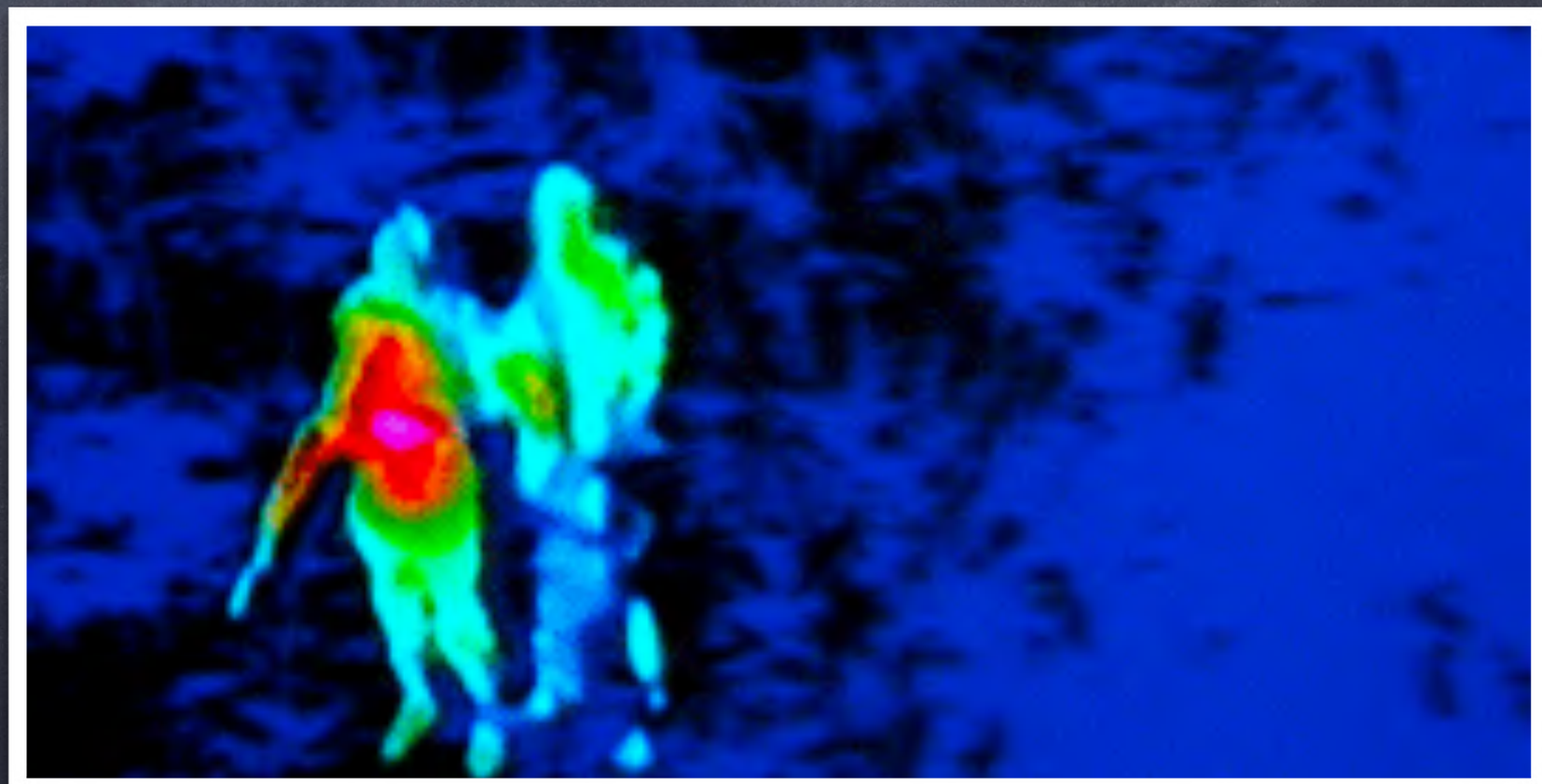
Galactic matter composition



Galactic matter composition



Galactic matter composition



Galactic matter composition

Galactic matter composition

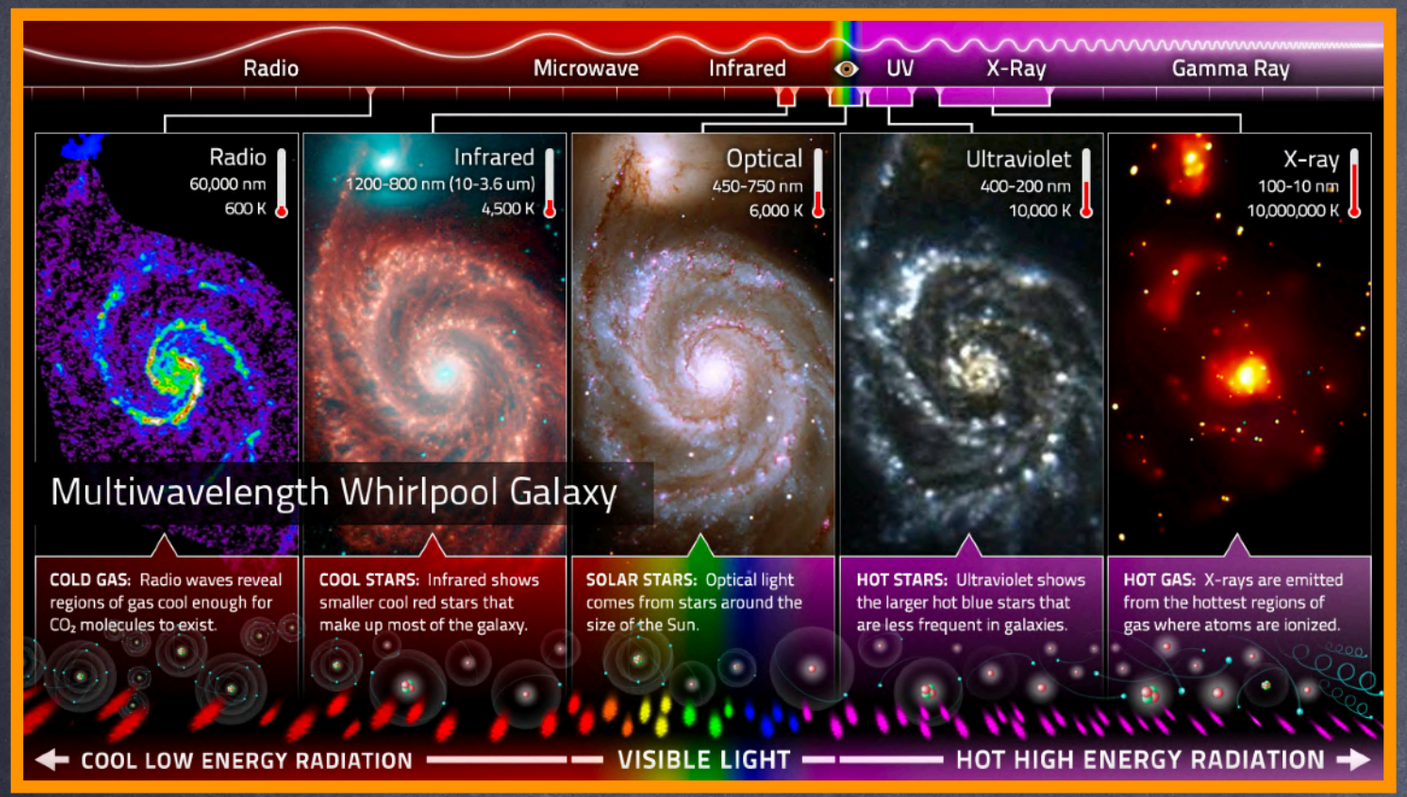
https://ecuip.lib.uchicago.edu/multiwavelength-astronomy/astrophysics/05.html

Galactic matter composition

https://ecuip.lib.uchicago.edu/multiwavelength-astronomy/astrophysics/05.html

Is there more matter we cannot see?

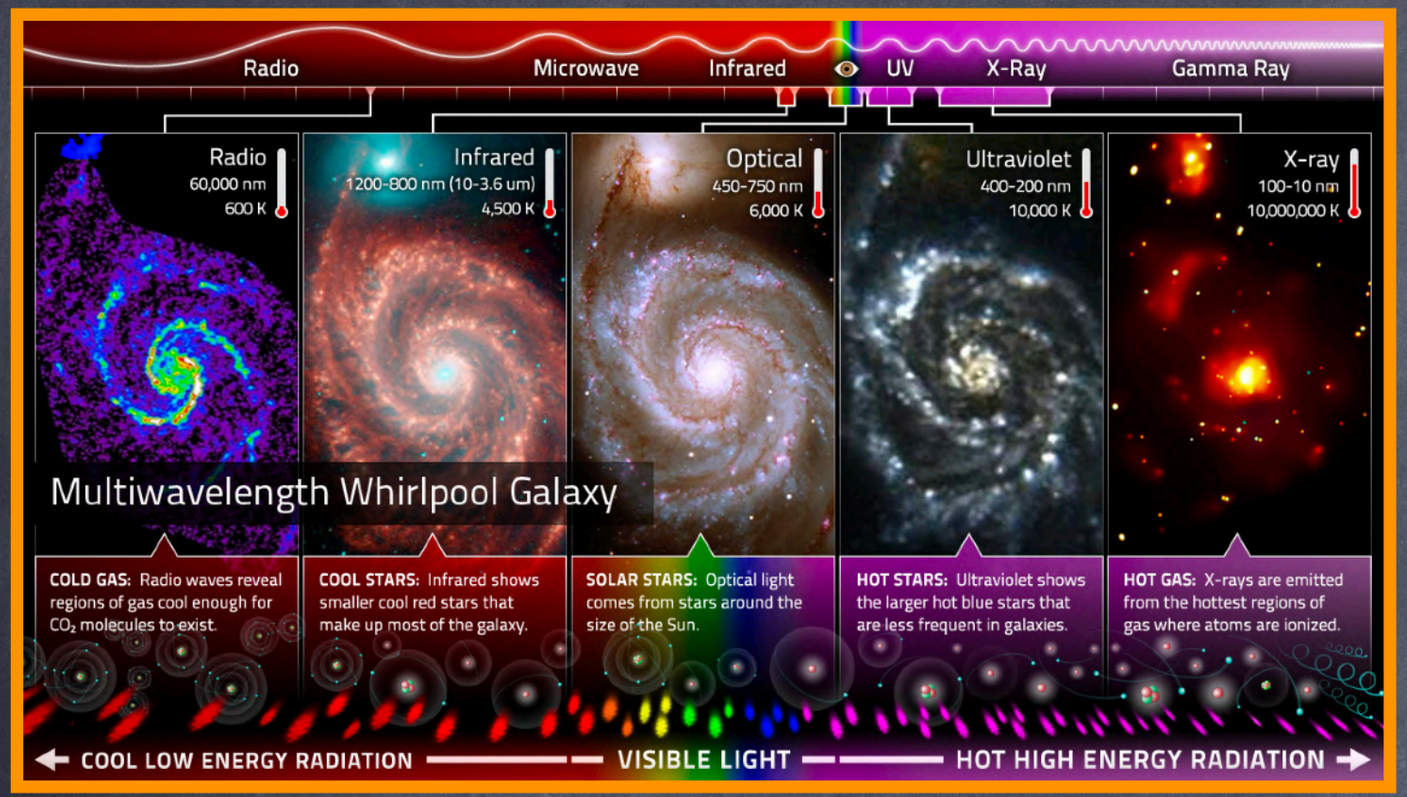
Galactic matter composition



https://ecuip.lib.uchicago.edu/multiwavelength-astronomy/astrophysics/05.html

Is there more matter we cannot see?

Galactic matter composition

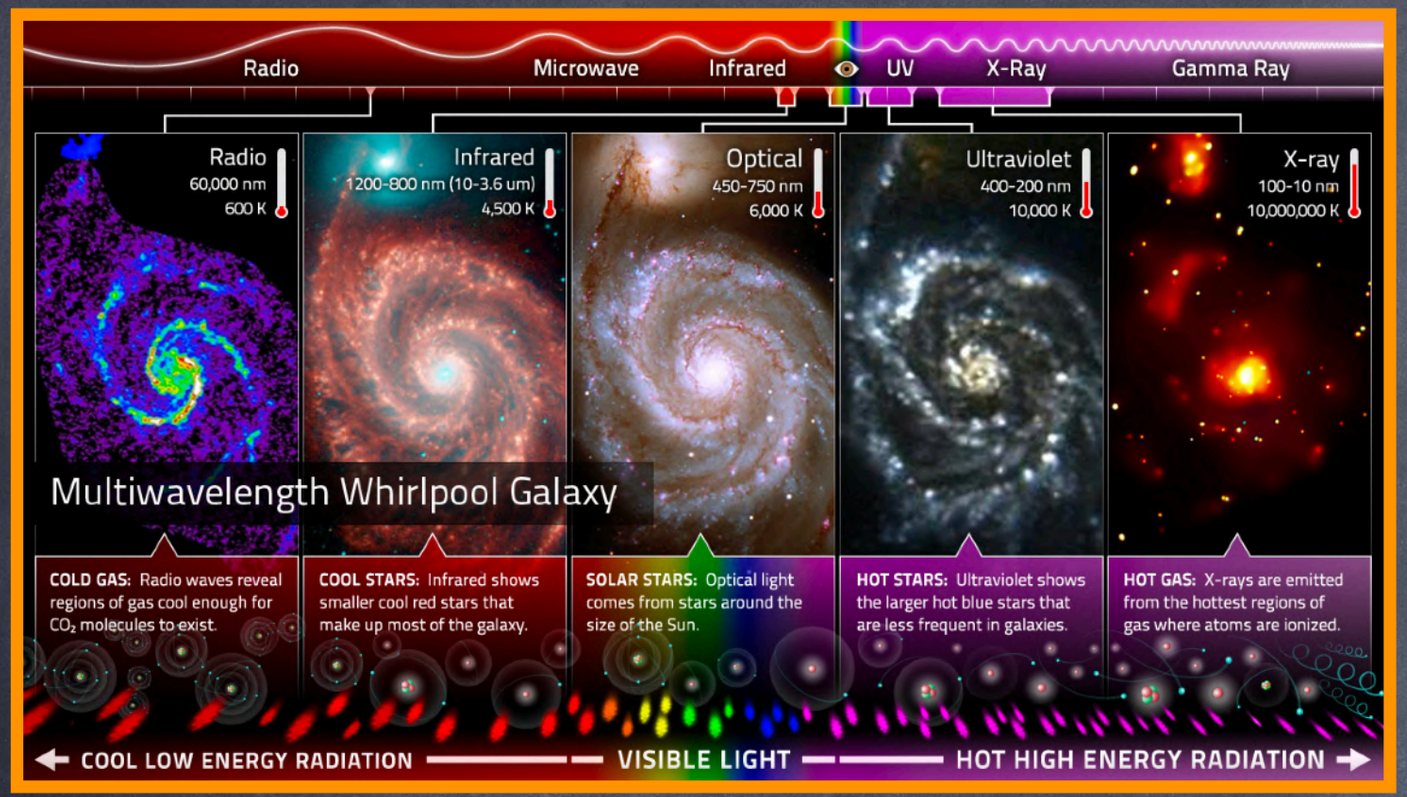


https://ecuip.lib.uchicago.edu/multiwavelength-astronomy/astrophysics/05.html

Is there more matter we cannot see?

Dark Matter!!!

Galactic matter composition



https://ecuip.lib.uchicago.edu/multiwavelength-astronomy/astrophysics/05.html

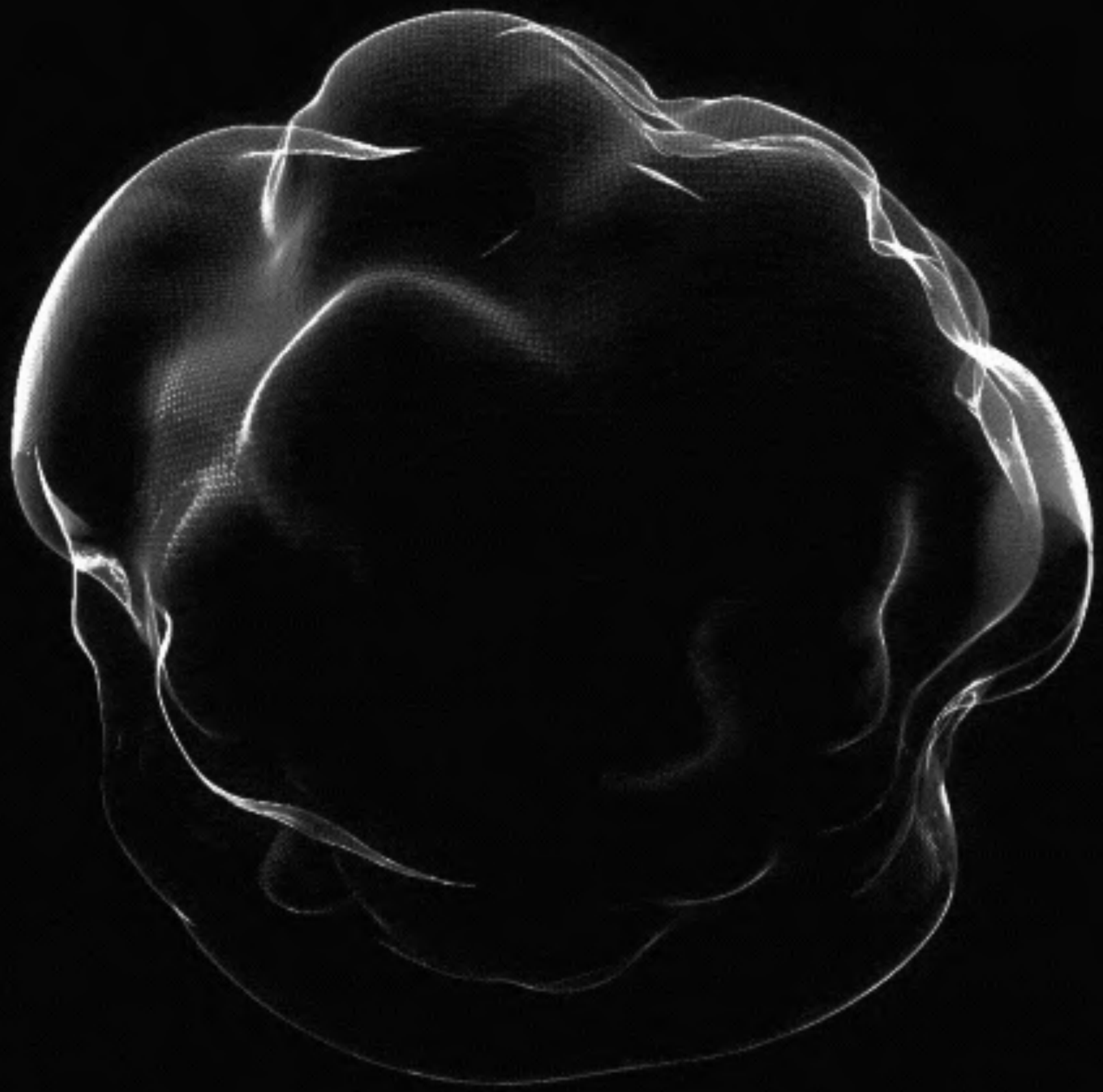
Is there more matter we cannot see?

Dark Matter!!!

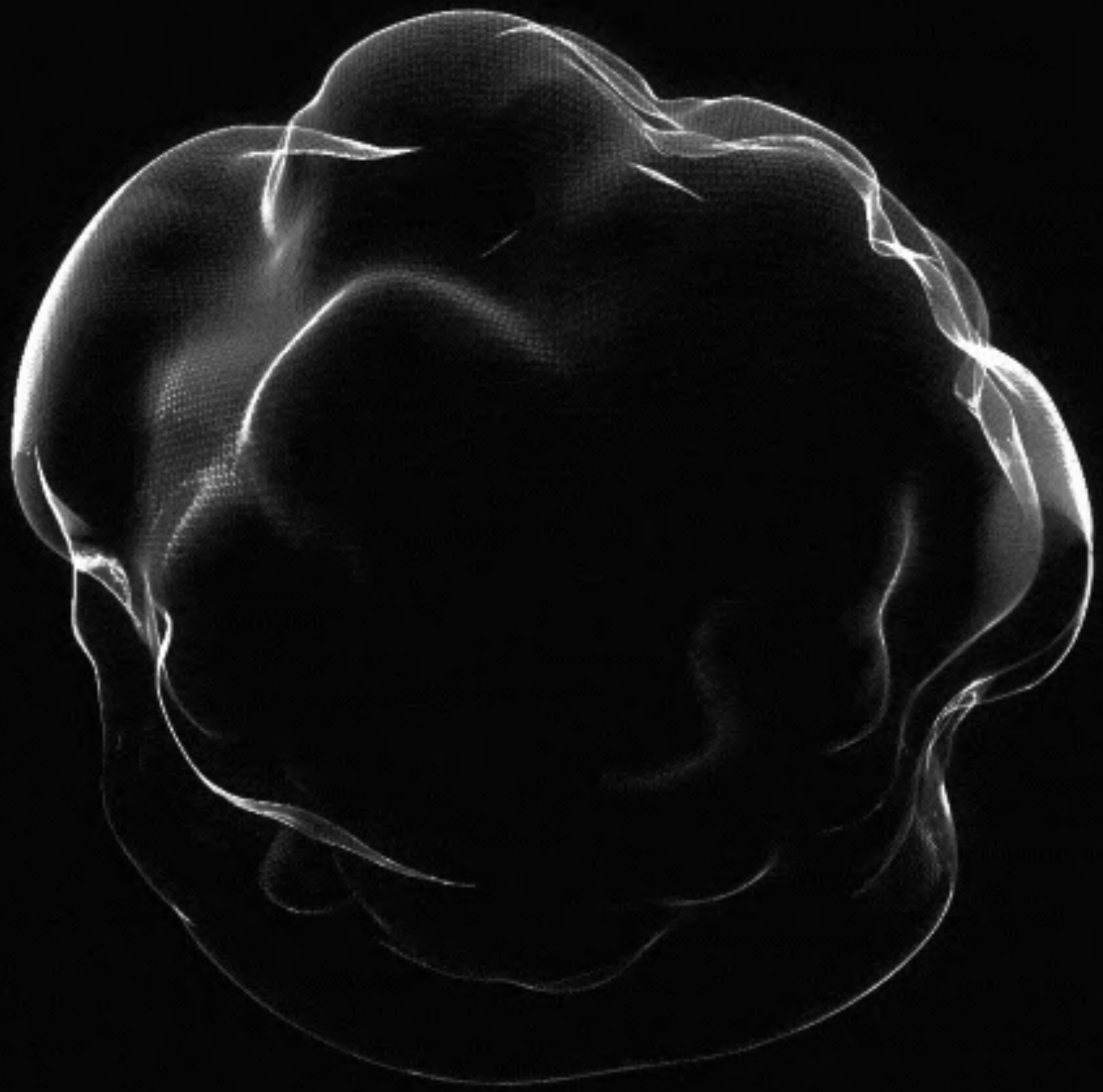
"It seems that much of the matter in spiral galaxies does not emit light. Moreover, it is not concentrated near the centers of the galaxies."

Vera Rubin, "Dark Matter in Spiral Galaxies", 1983.

Act III: Dark Matter



Act III: Dark Matter



What is Dark Matter?

What is Dark Matter?

NOBODY KNOWS YET!!!

What is Dark Matter?

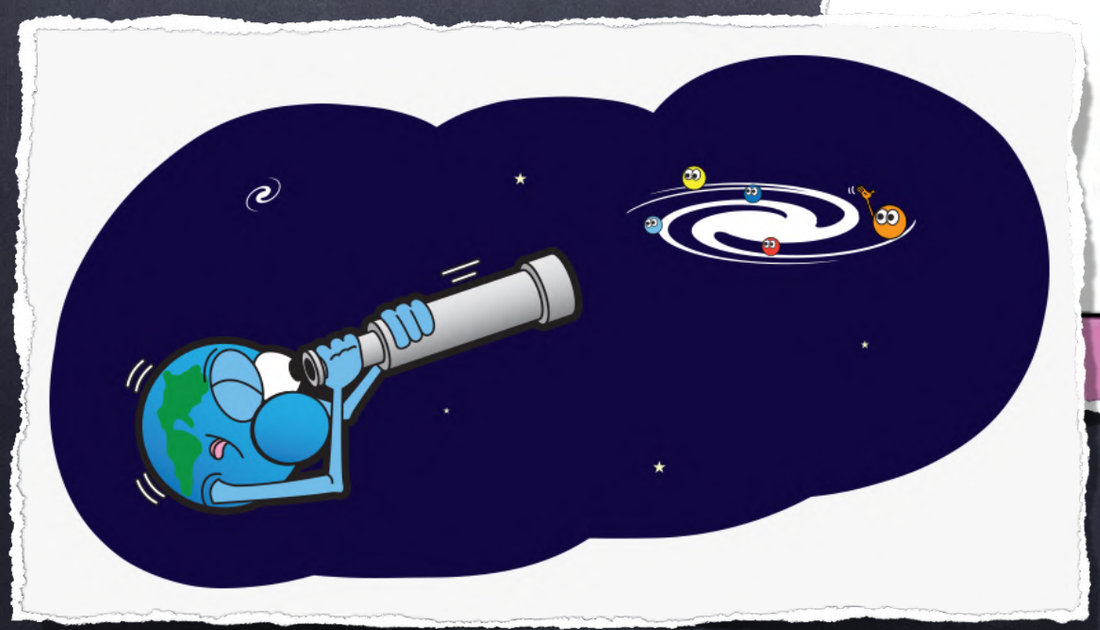
NOBODY KNOWS YET!!!

Although dark matter exists in many large-scale structures in the universe —not just galaxies—we currently only know that it is invisible and that it interacts via gravity.

What is Dark Matter?

NOBODY KNOWS YET!!!

Although dark matter exists in many large-scale structures in the universe —not just galaxies—we currently only know that it is invisible and that it interacts via gravity.



Vera C. Rubin Observatory

Legacy Survey of Space and Time (LSST)

Located on Cerro Pachón, Chile, it will carry out a 10-year survey of the entire southern sky beginning in 2026.

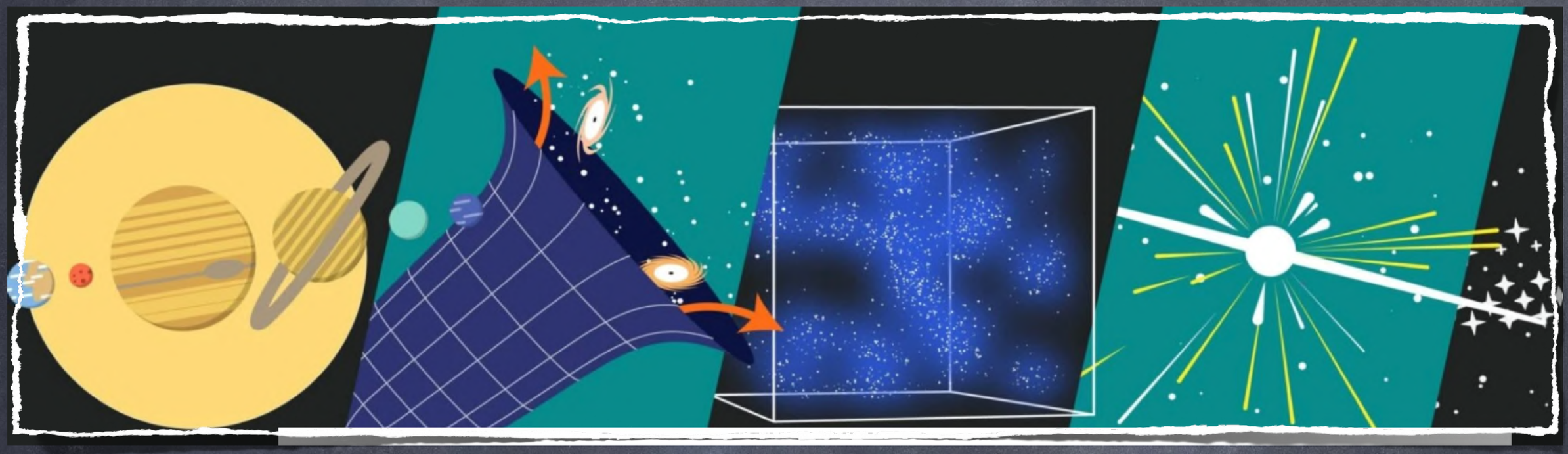
Vera C. Rubin Observatory

Legacy Survey of Space and Time (LSST)

Located on Cerro Pachón, Chile, it will carry out a 10-year survey of the entire southern sky beginning in 2026.

Vera C. Rubin Observatory

Legacy Survey of Space and Time (LSST)



Four major scientific goals:

- Understanding the nature of dark matter and dark energy.
- Creating an inventory of the Solar System.
- Mapping the Milky Way.
- Exploring objects that change position or brightness over time.

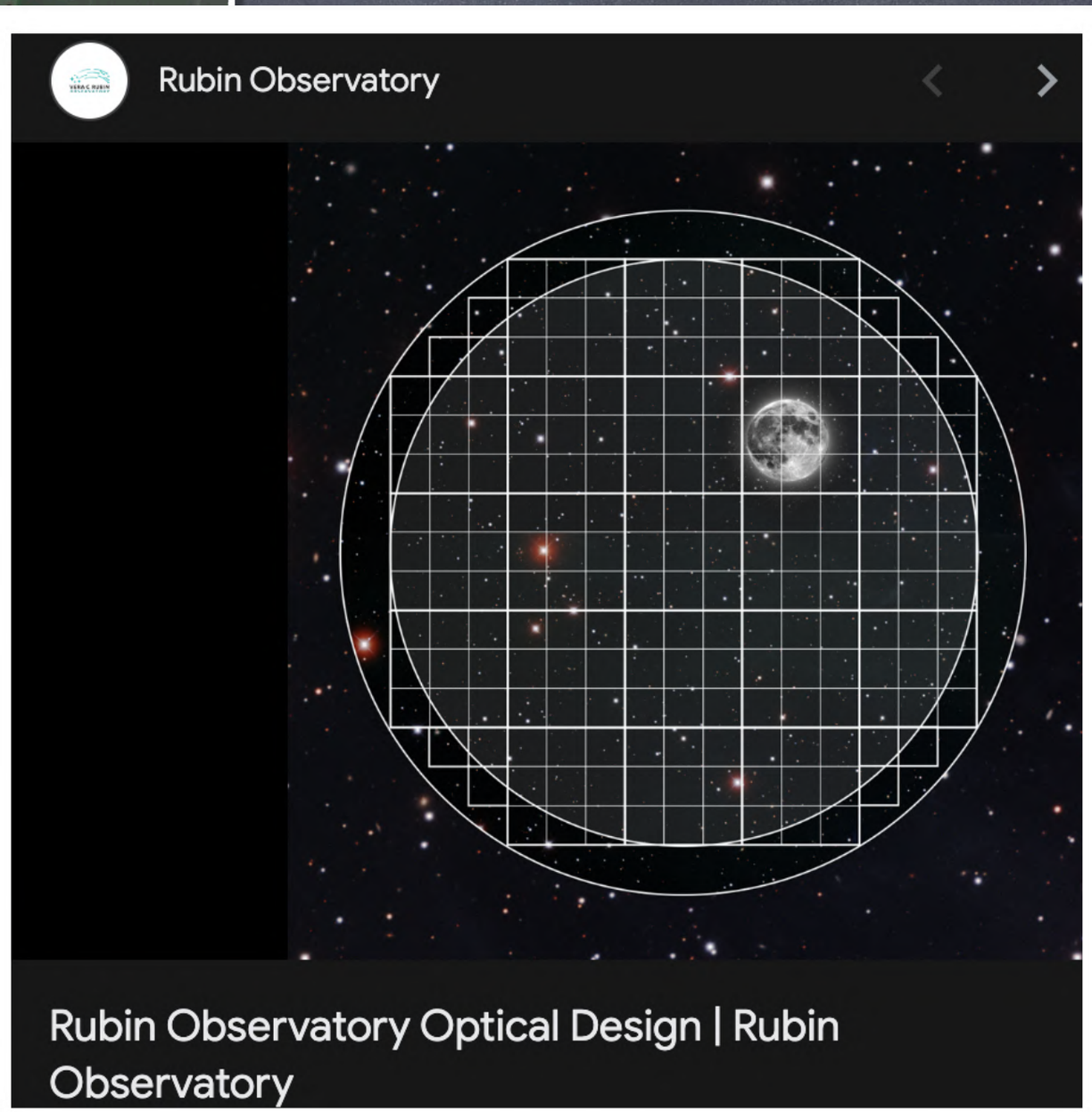
Vera C. Rubin Observatory

Weighing roughly 2,800 kg and the size of a compact car, the camera features a 3,200-megapixel sensor.

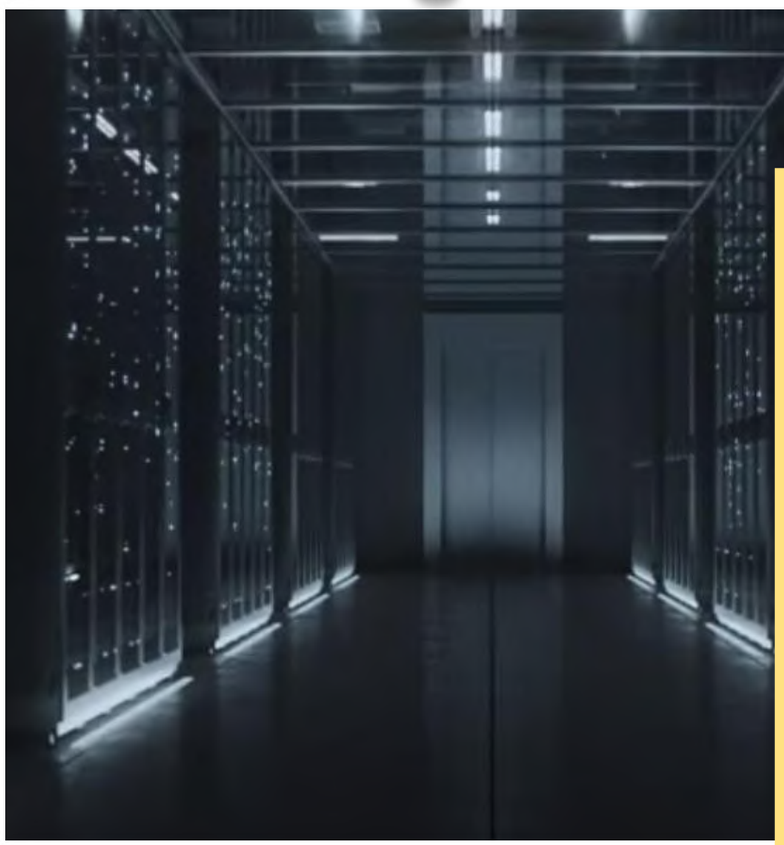
Vera C. Rubin Observatory

Weighing roughly 2,800 kg and the size of a compact car, the camera features a 3,200-megapixel sensor.

The camera's field of view spans an area just a bit larger than 40 full moons.

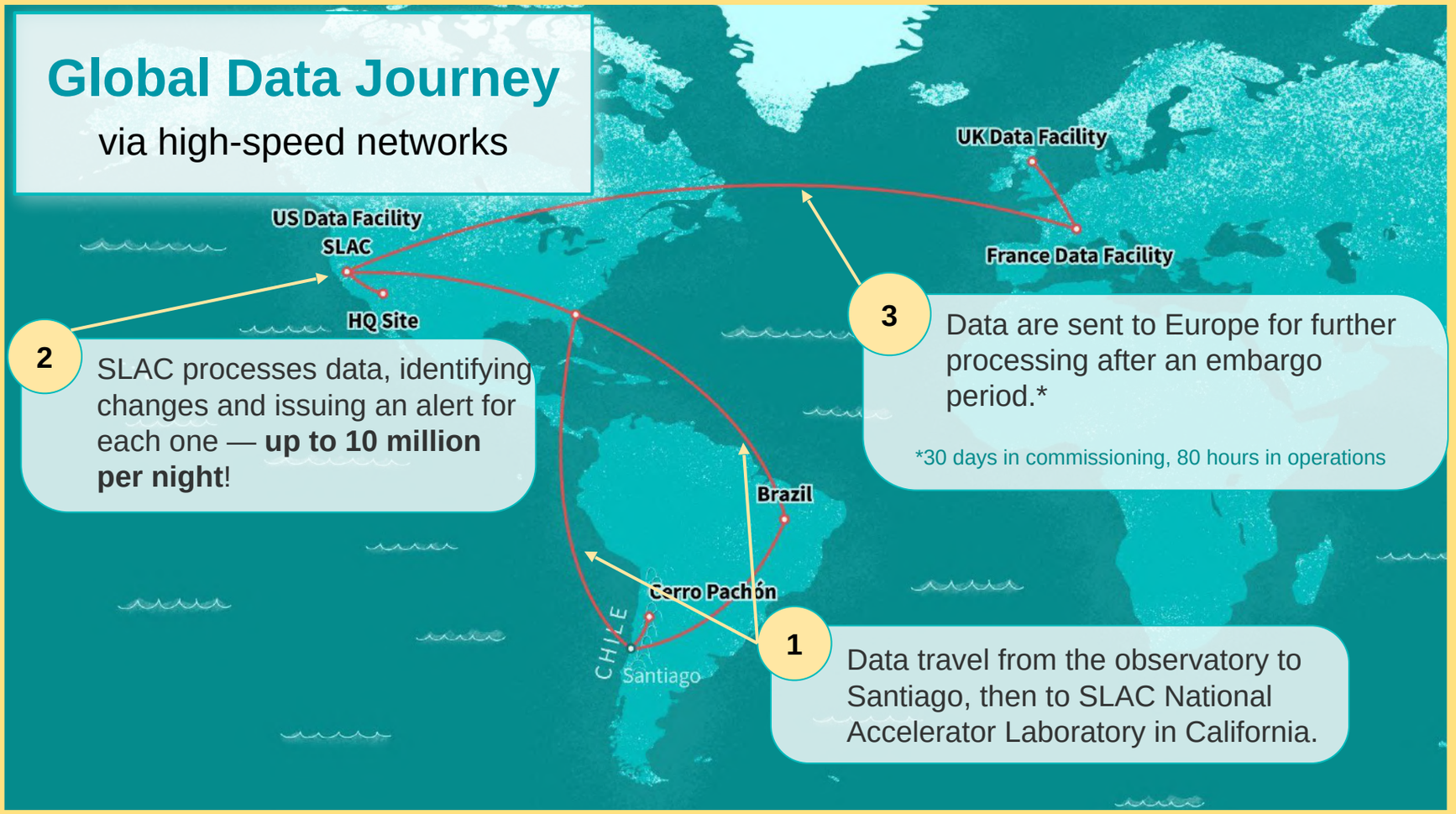


Vera C. Rubin Observatory



Global Data Journey

via high-speed networks



2 SLAC processes data, identifying changes and issuing an alert for each one — **up to 10 million per night**!

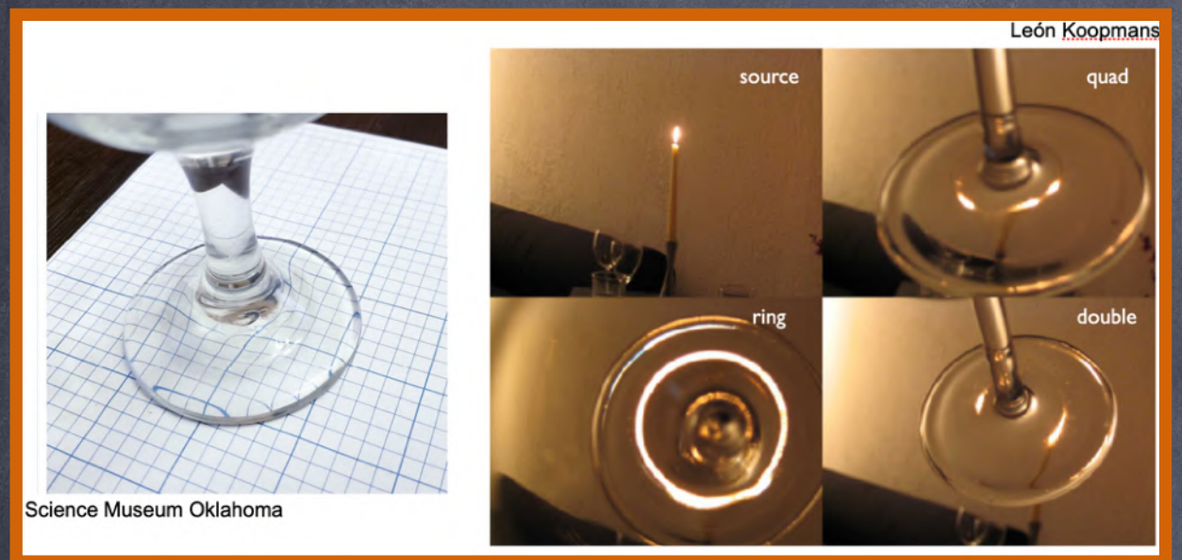
3 Data are sent to Europe for further processing after an embargo period.*

*30 days in commissioning, 80 hours in operations

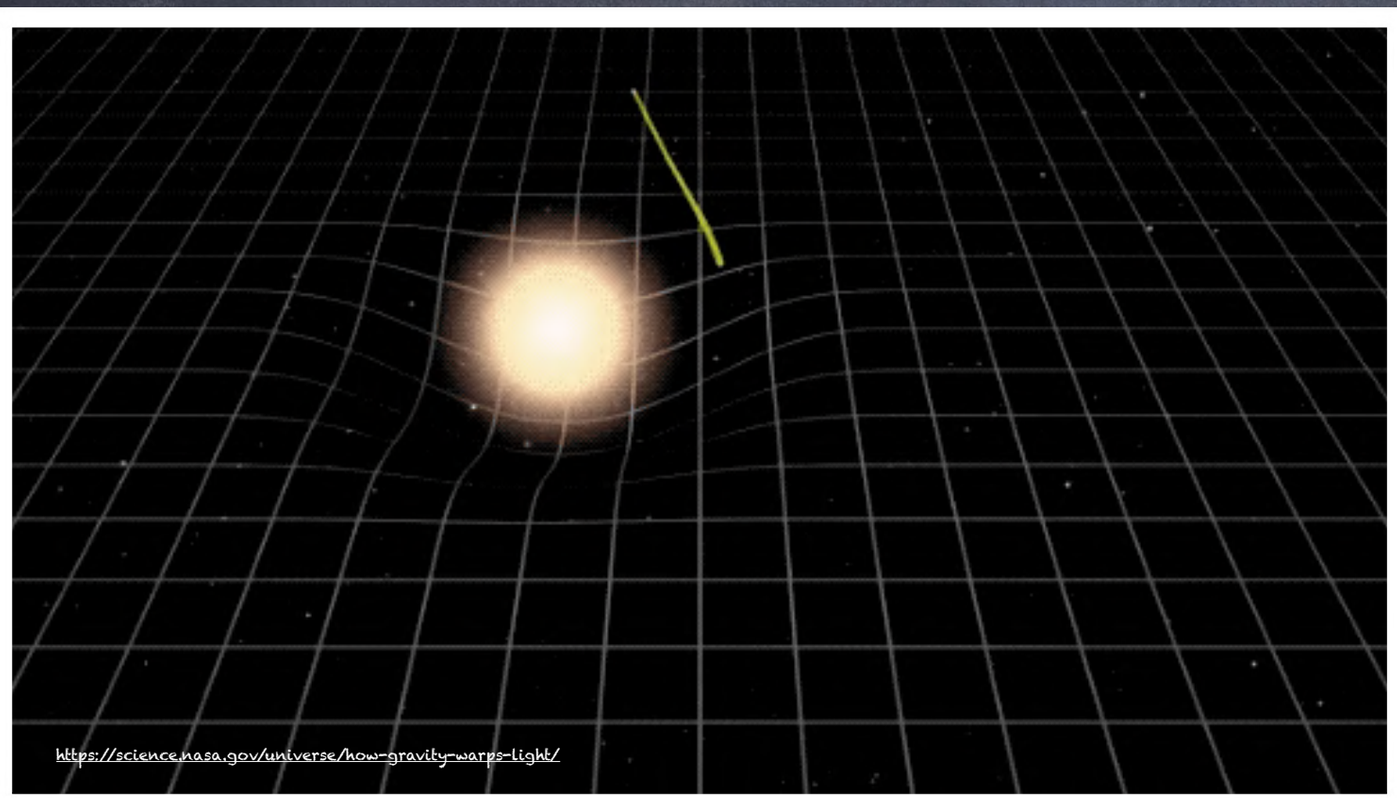
1 Data travel from the observatory to Santiago, then to SLAC National Accelerator Laboratory in California.

It will produce about 20 terabytes of data every day, which is like watching Netflix continuously for over three years or listening to Spotify for roughly 50 years.

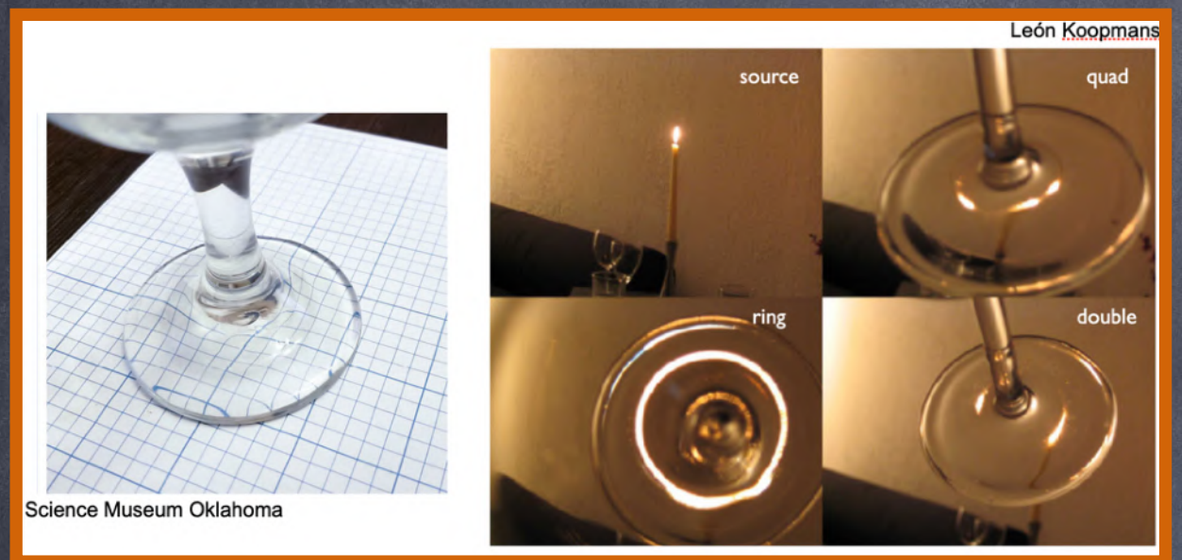
How will the Vera C. Rubin Observatory look for dark matter?



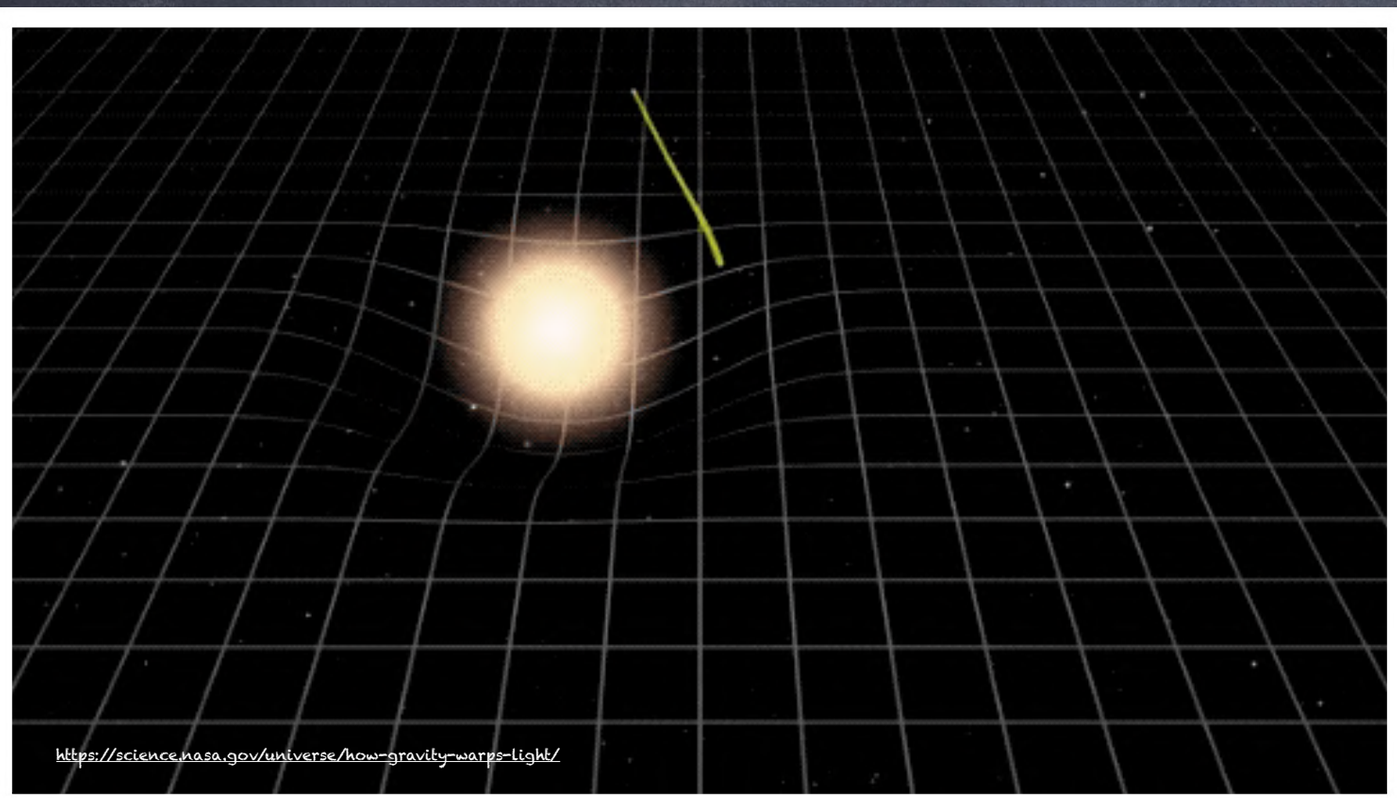
Gravitational Lenses



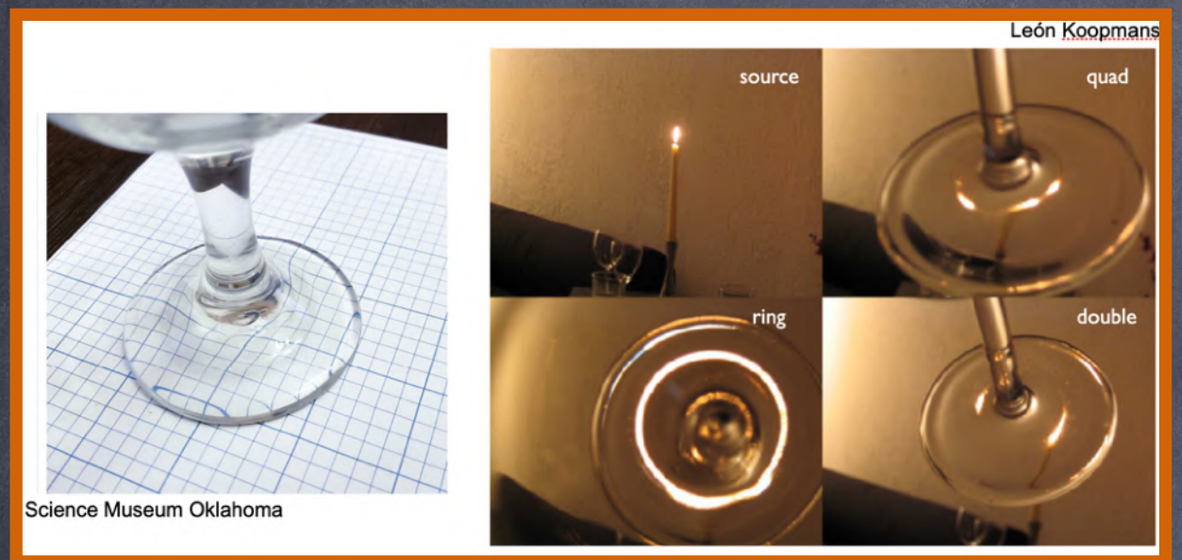
How will the Vera C. Rubin Observatory look for dark matter?



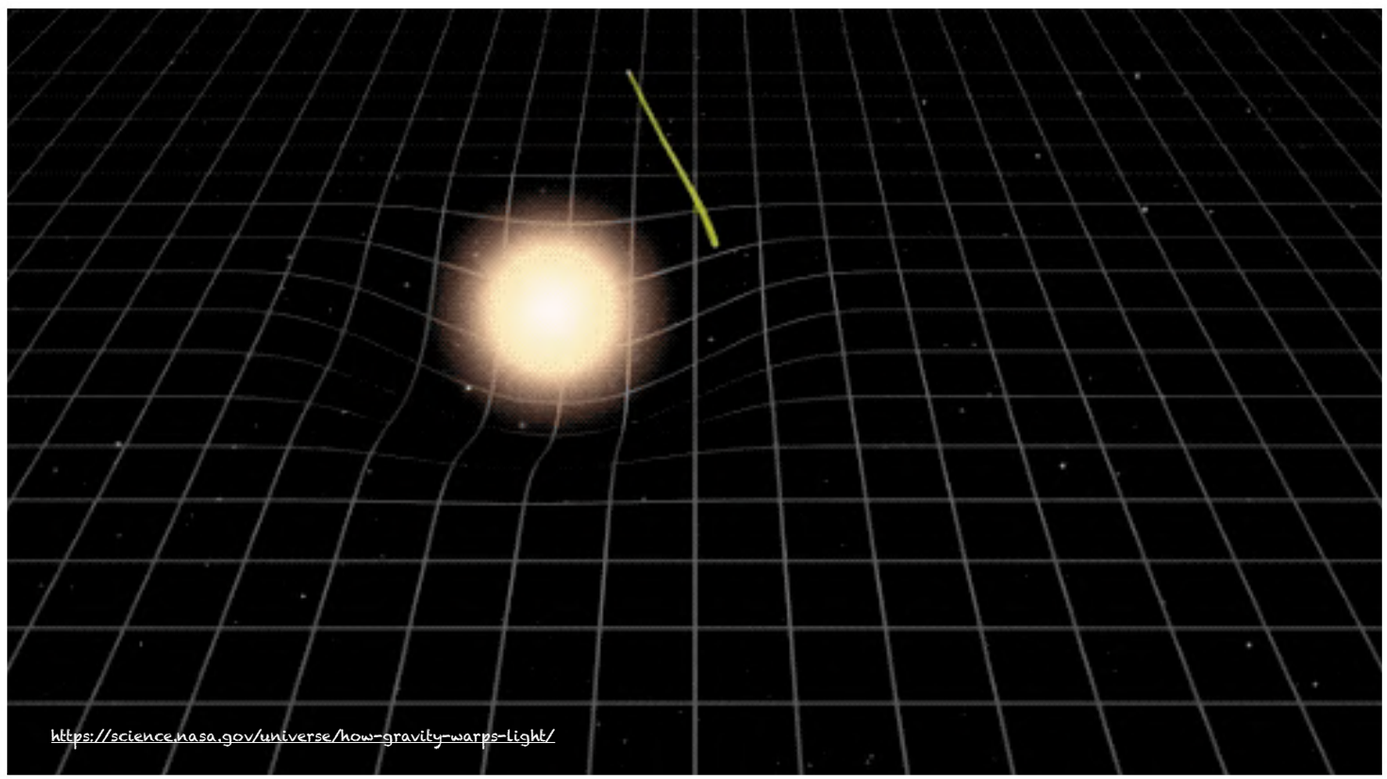
Gravitational Lenses

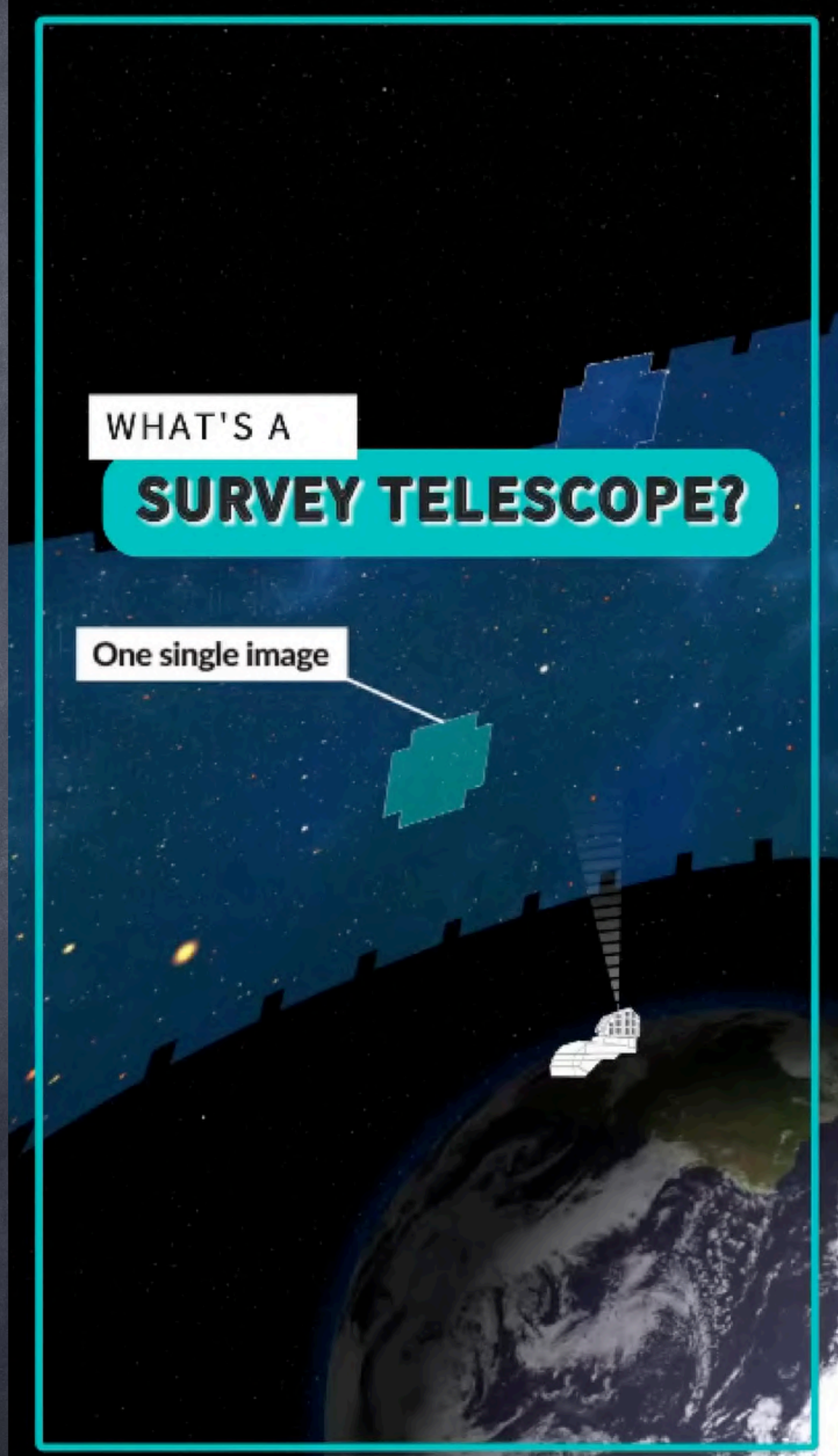


How will the Vera C. Rubin Observatory look for dark matter?

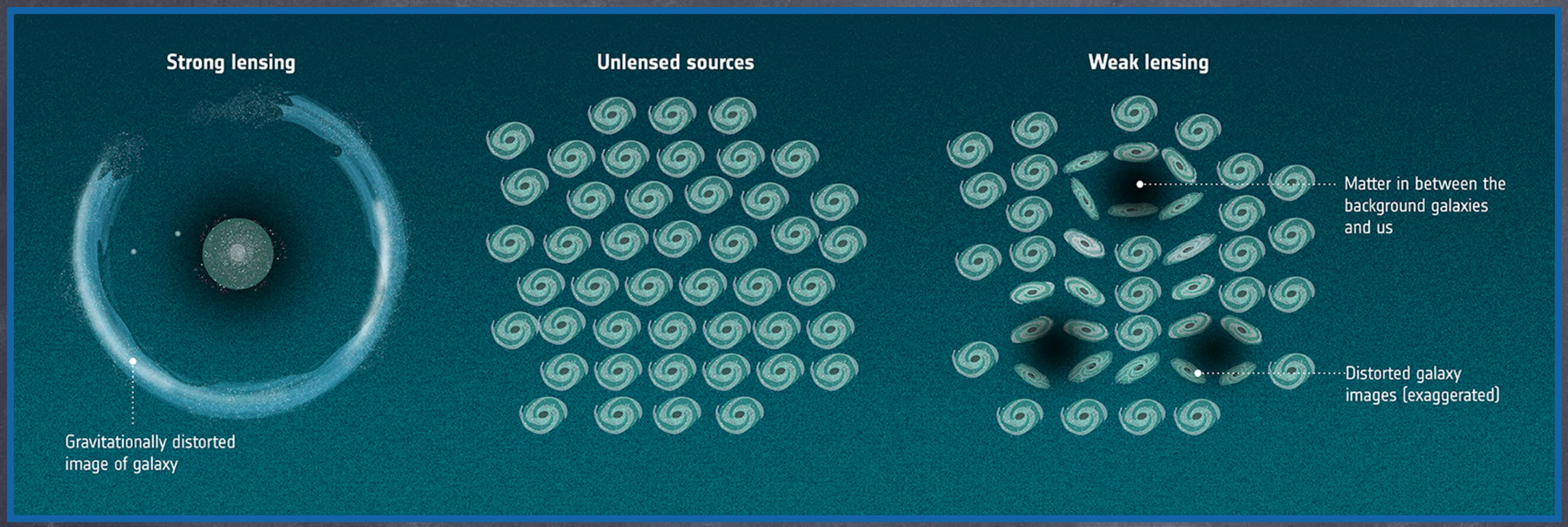


Gravitational Lenses

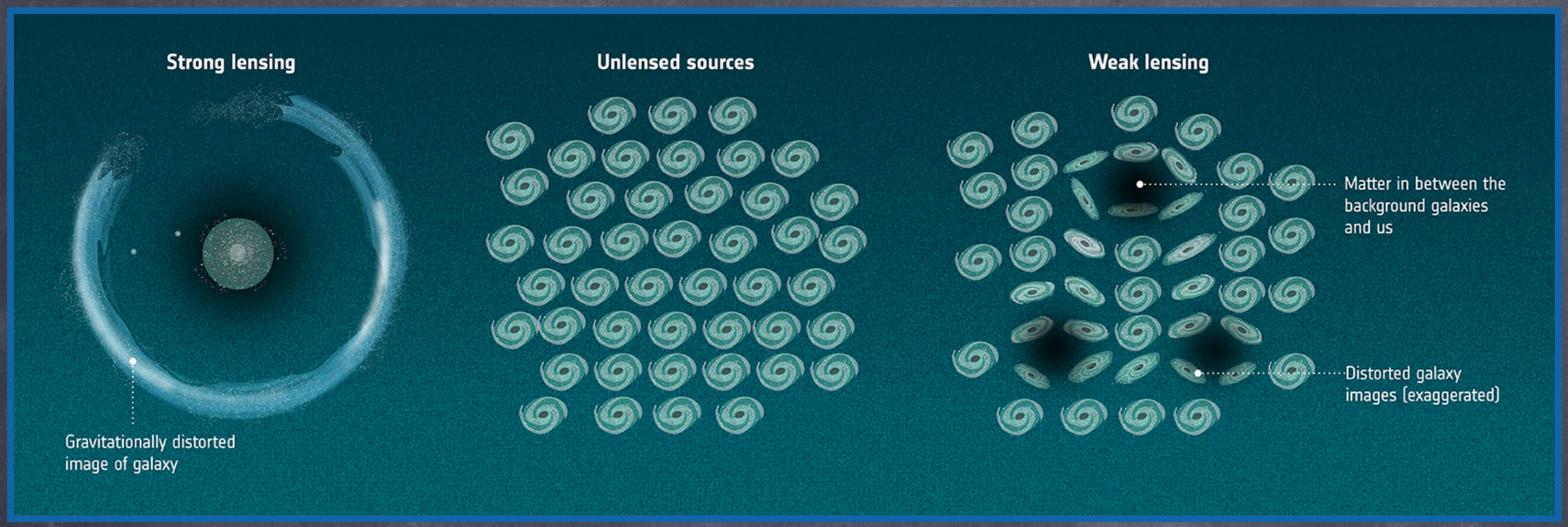




How will the Vera C. Rubin Observatory look for dark matter?



How will the Vera C. Rubin Observatory look for dark matter?



Credits: ESA/Hubble, NASA, Suyu et al.

Credits: NASA/ESA


https://rubinobservatory.org/es
Credits: NSF-DOE Vera C. Rubin Observatory

@rubin_observatory

@VRubinObs

Take control of the Vera Rubin Telescope

SCAN ME

vaso cósmico

Science outreach articles

"Don't shoot for the stars, we already know what's there. Shoot for the space in between because that's where the real mystery lies."

—Vera C. Rubin

https://rubinobservatory.org/es

Credits: H.Stockebrand/RubinObs/NOIRLab/SLAC/DOE/NSF/AURA

Thank you for your kind attention!!!

Contact: linares.francisco@gmail.com

This work has received funding from the PID2023-146872OB-I00-DyCMaMod

Thank you for your kind attention!!!

Contact: linares.francisco@gmail.com

This work has received funding from the PID2023-146872OB-I00-DyCMaMod