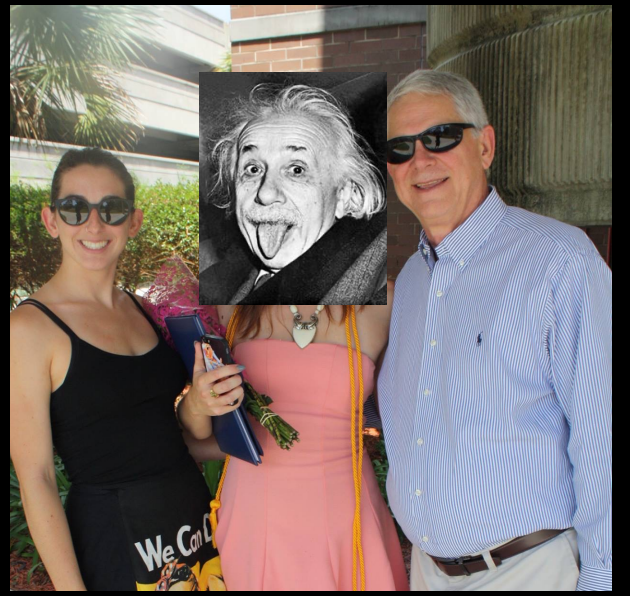
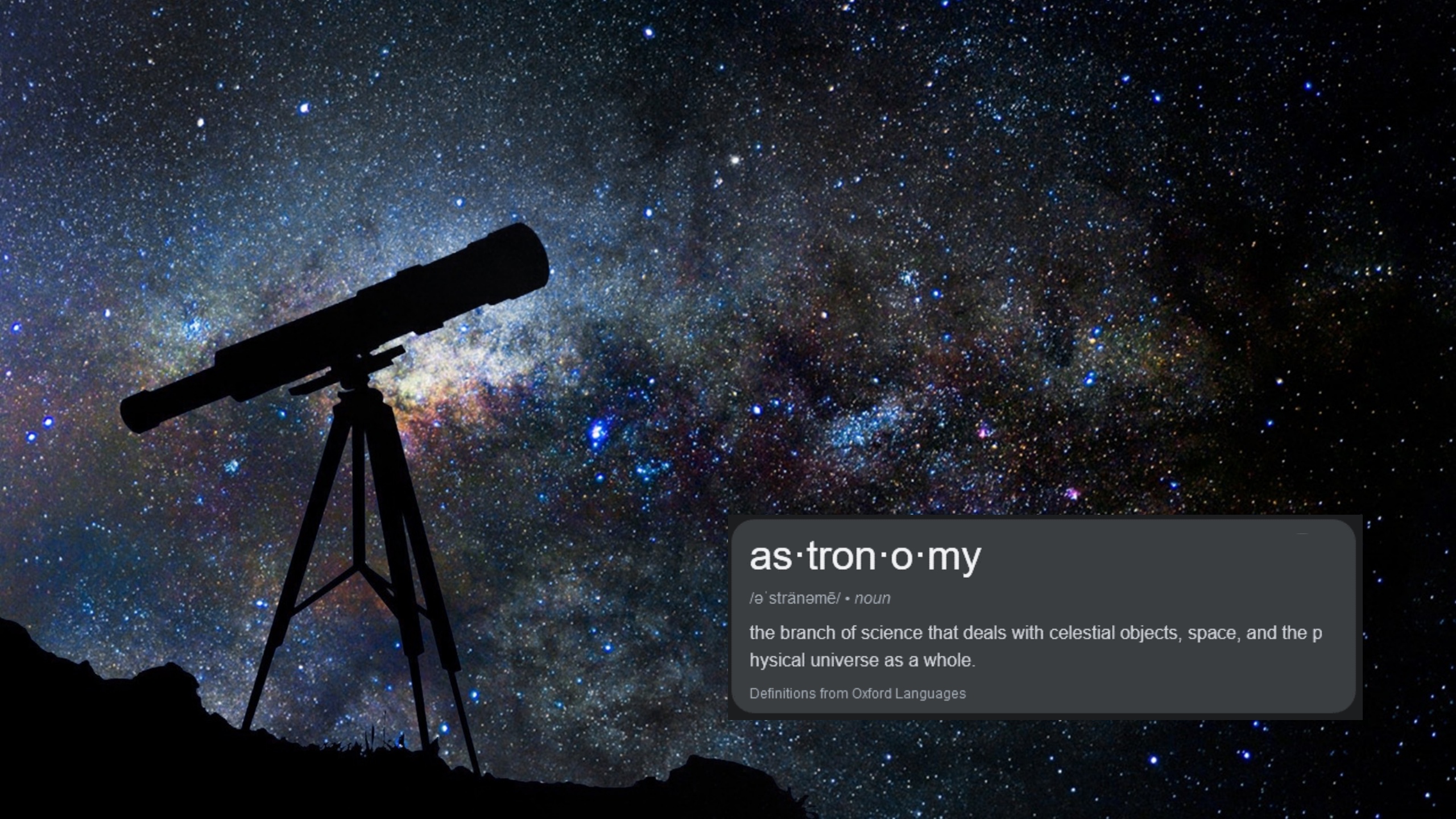

Gravity
and
Dark Matter

X

✓




as·tron·o·my
/əˈstränəmē/ • noun
the branch of science that deals with celestial objects, space, and the p
hysical universe as a whole.
Definitions from Oxford Languages

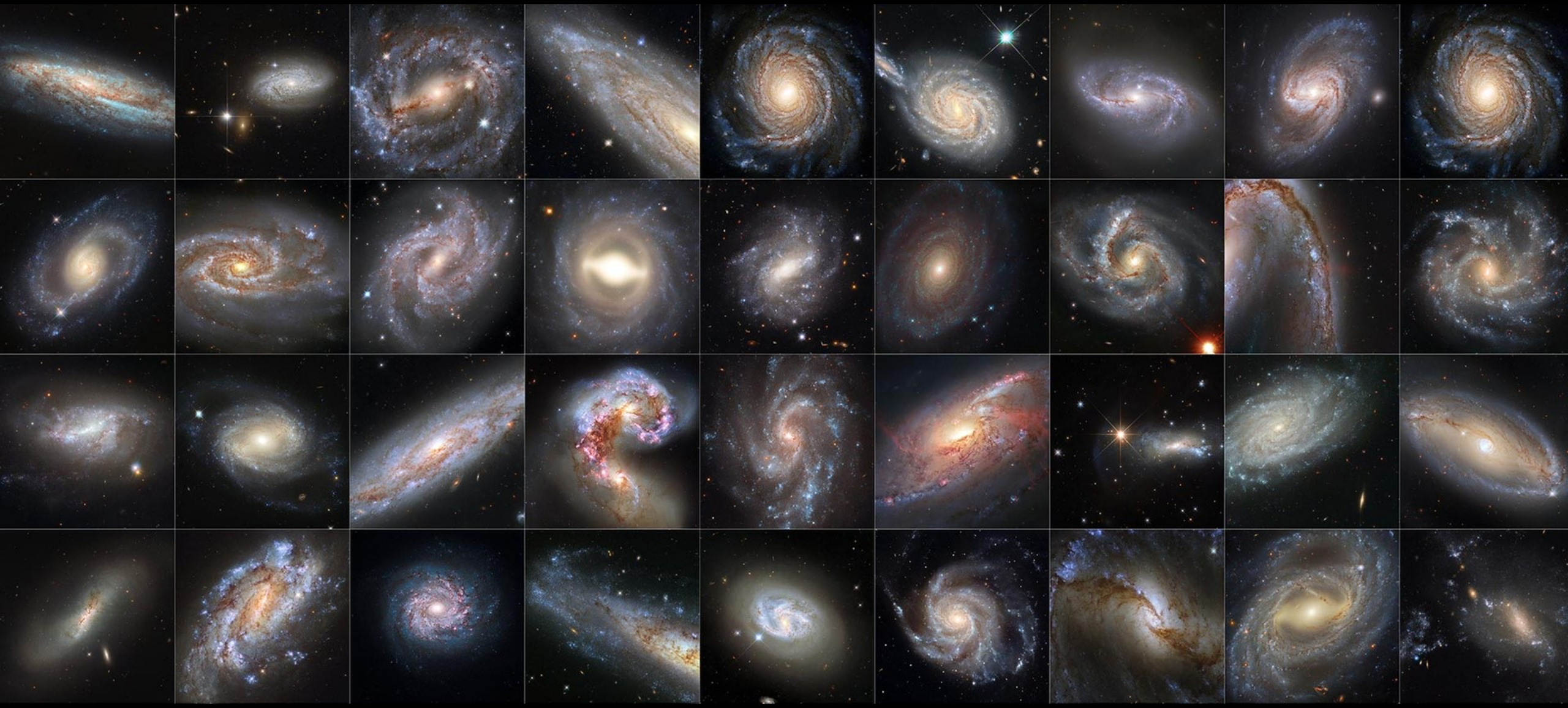

The Milky Way


INNER-CITY SKY
CITY SKY
SUBURBAN SKY
RURAL SKY
EXCELLENT DARK SKY

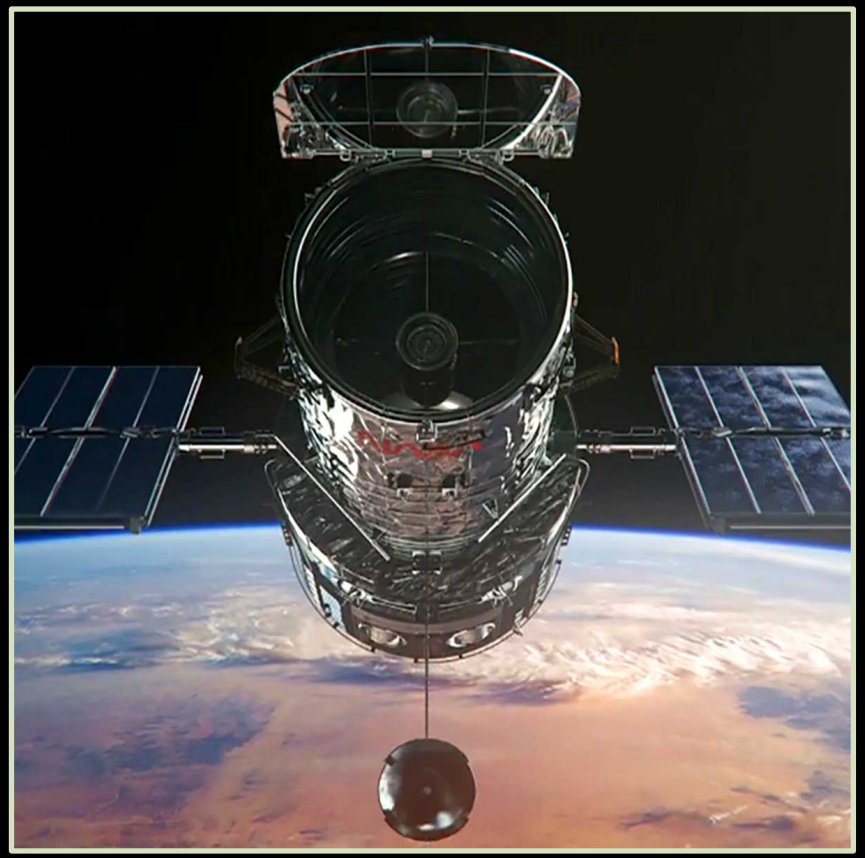

The Milky Way

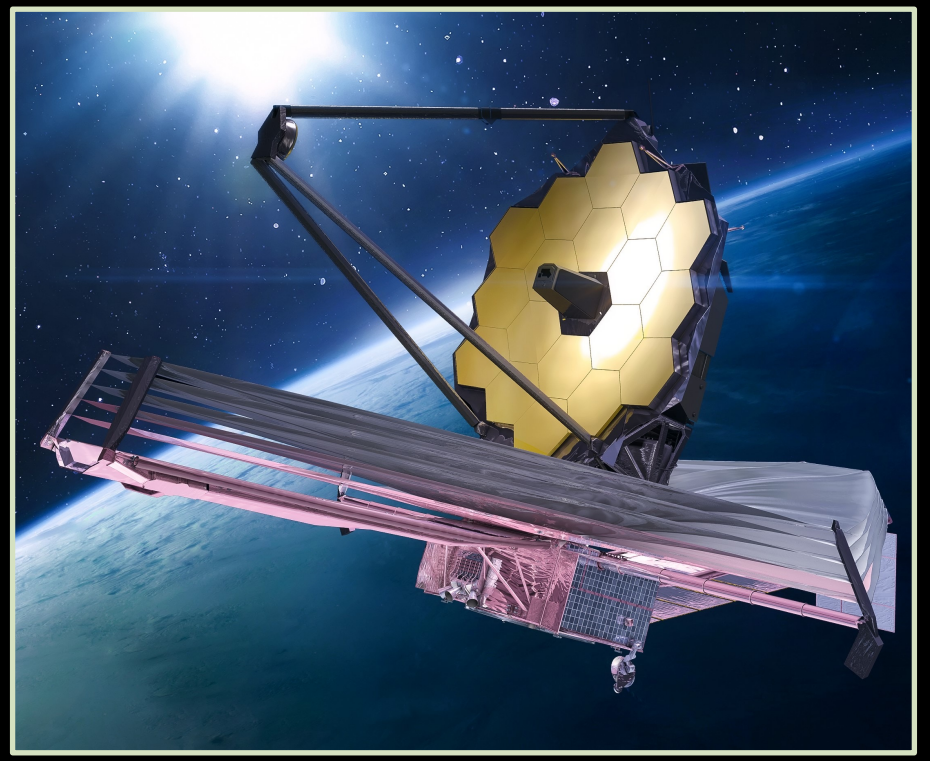
The night sky viewed from planet Earth

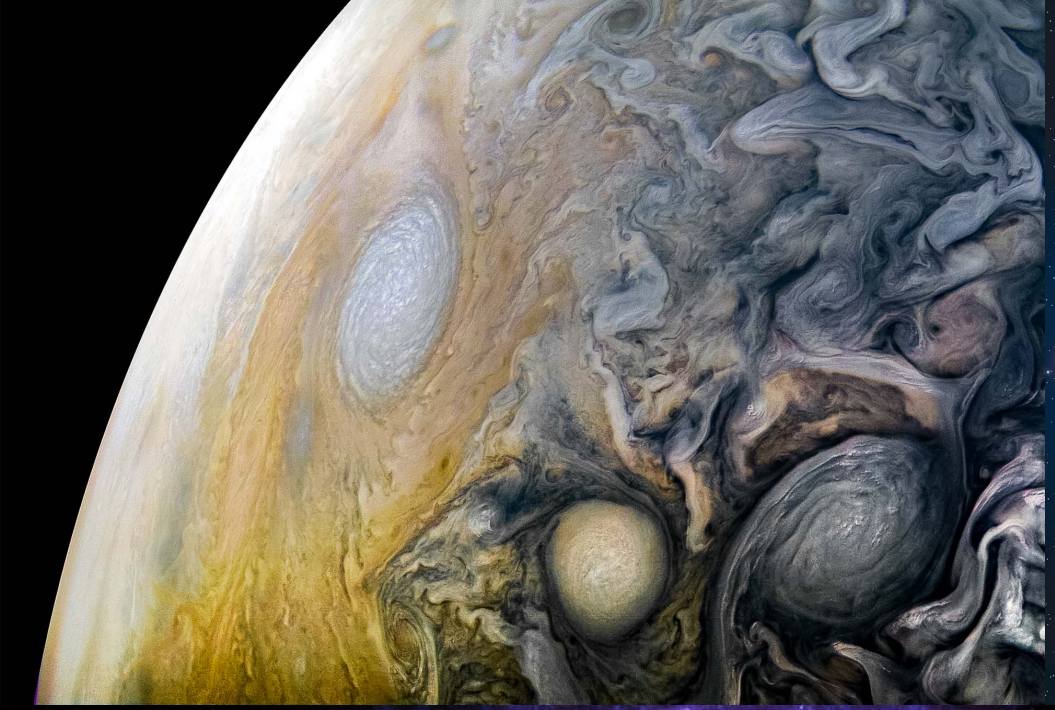
The Milky Way viewed from outside

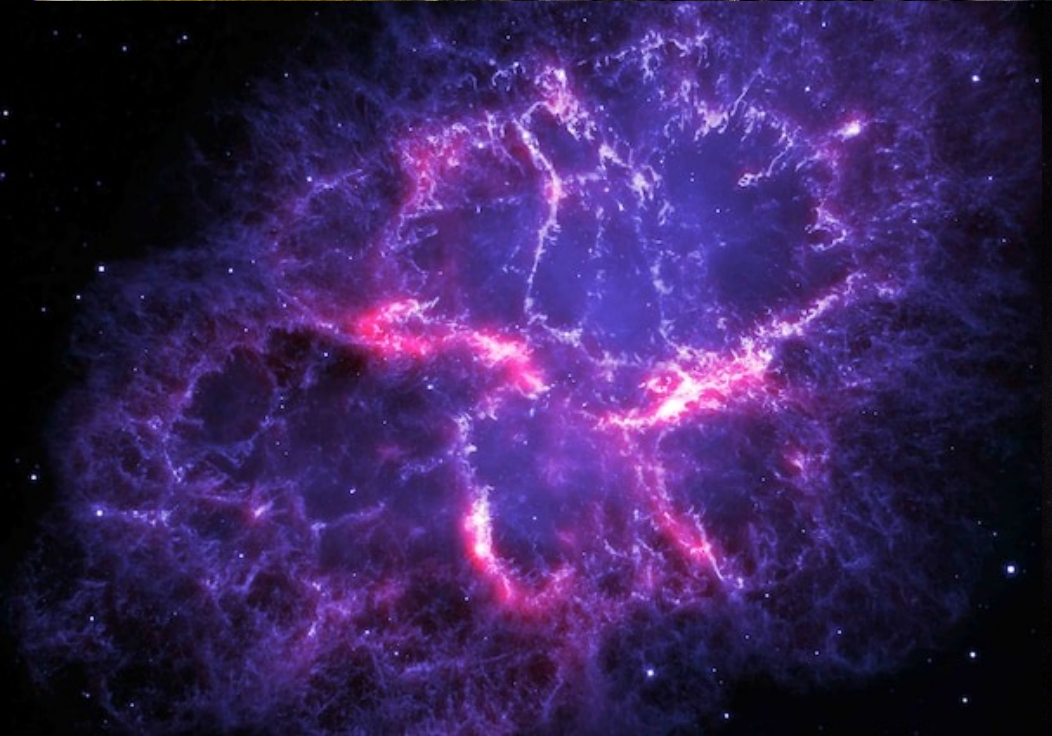


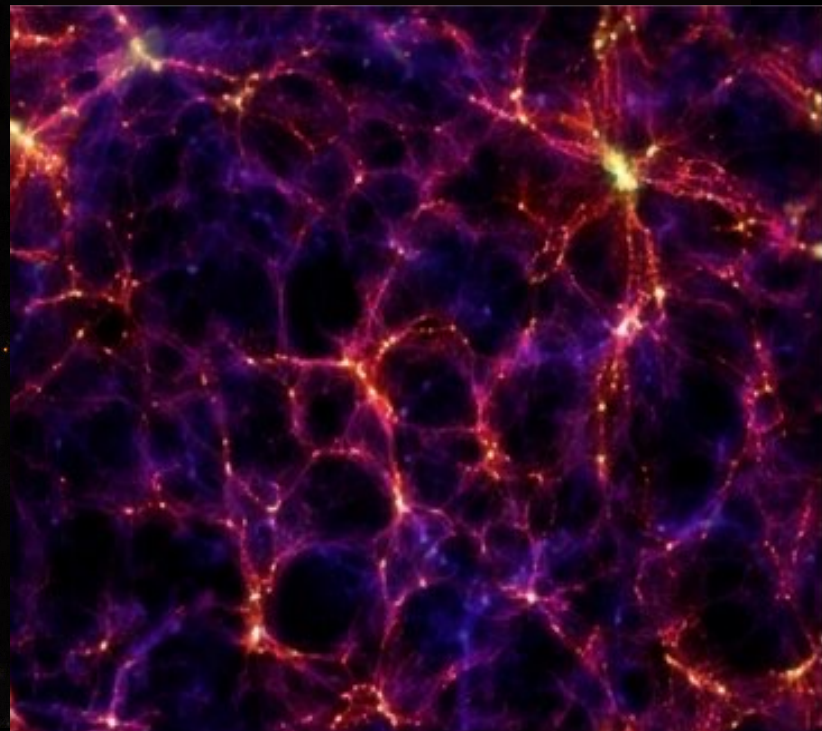

INNER-CITY SKY
URAL SKY
EXCELLENT DARK SKY





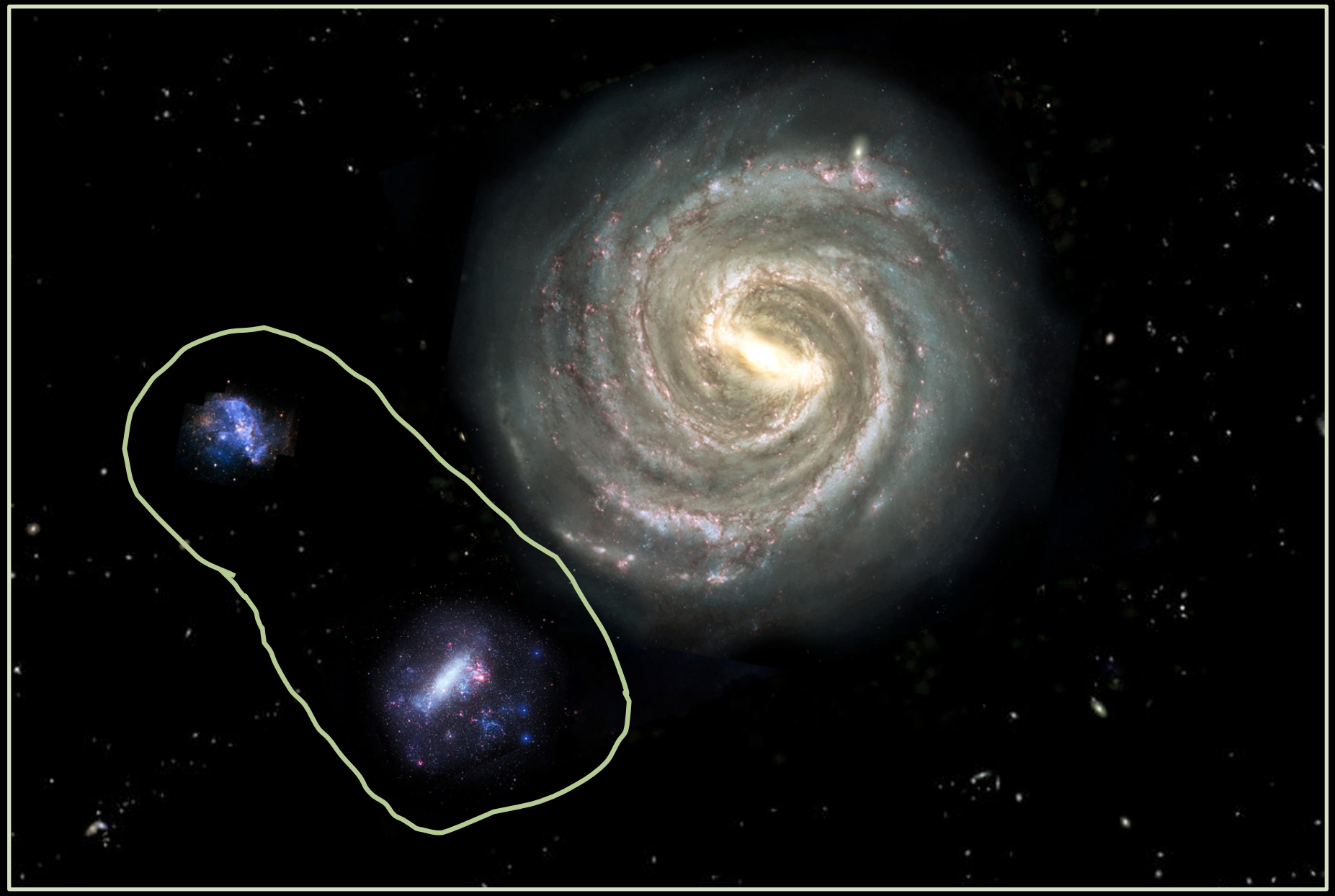






Dark Matter

Dwarf Galaxies



Force of Gravity

$$F_G = G \frac{m_1 m_2}{d^2}$$

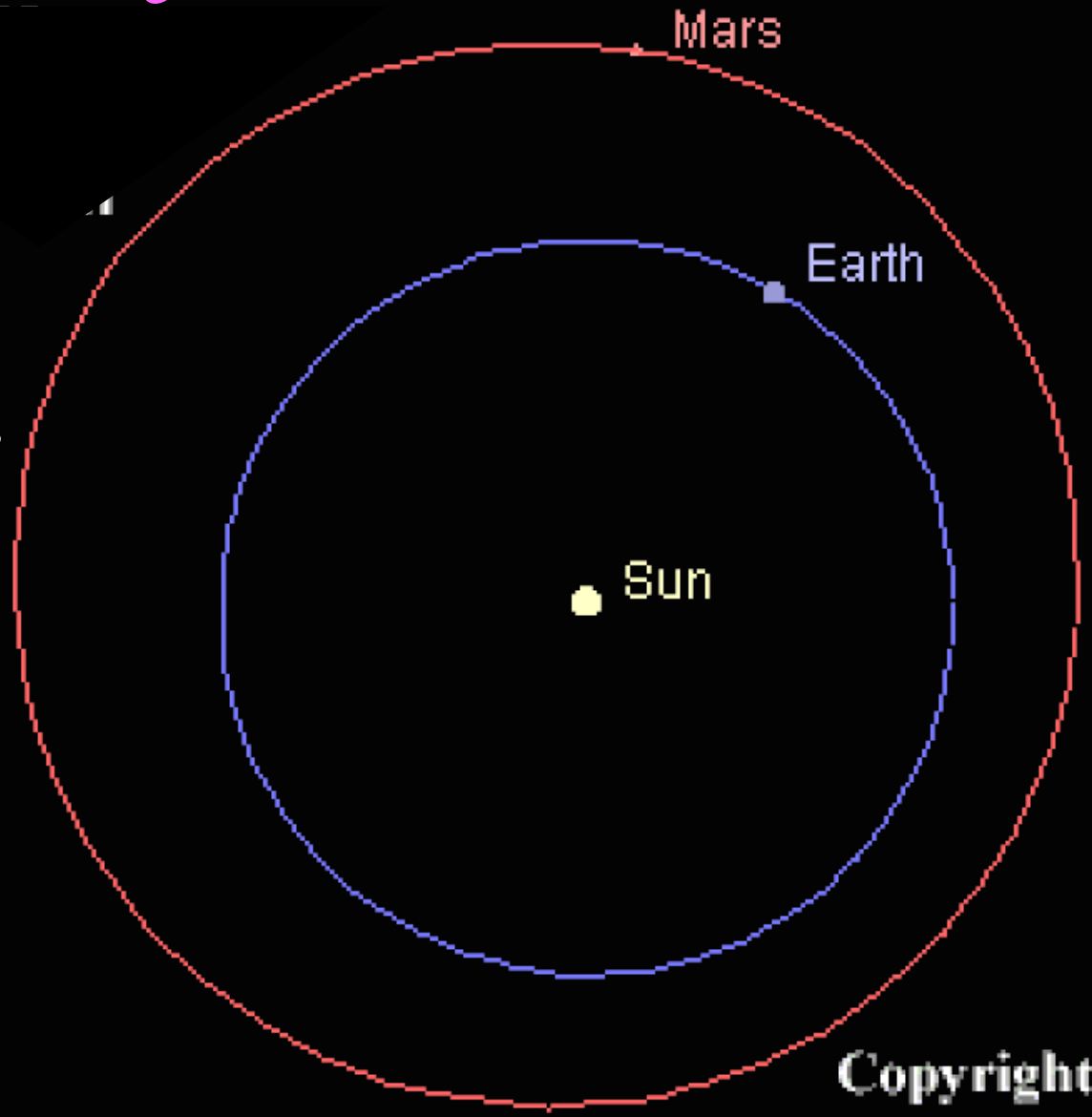
Force of Gravity + motion

$$F_G = G\frac{m_1 m_2}{d^2} = m_1 a$$

Force on object

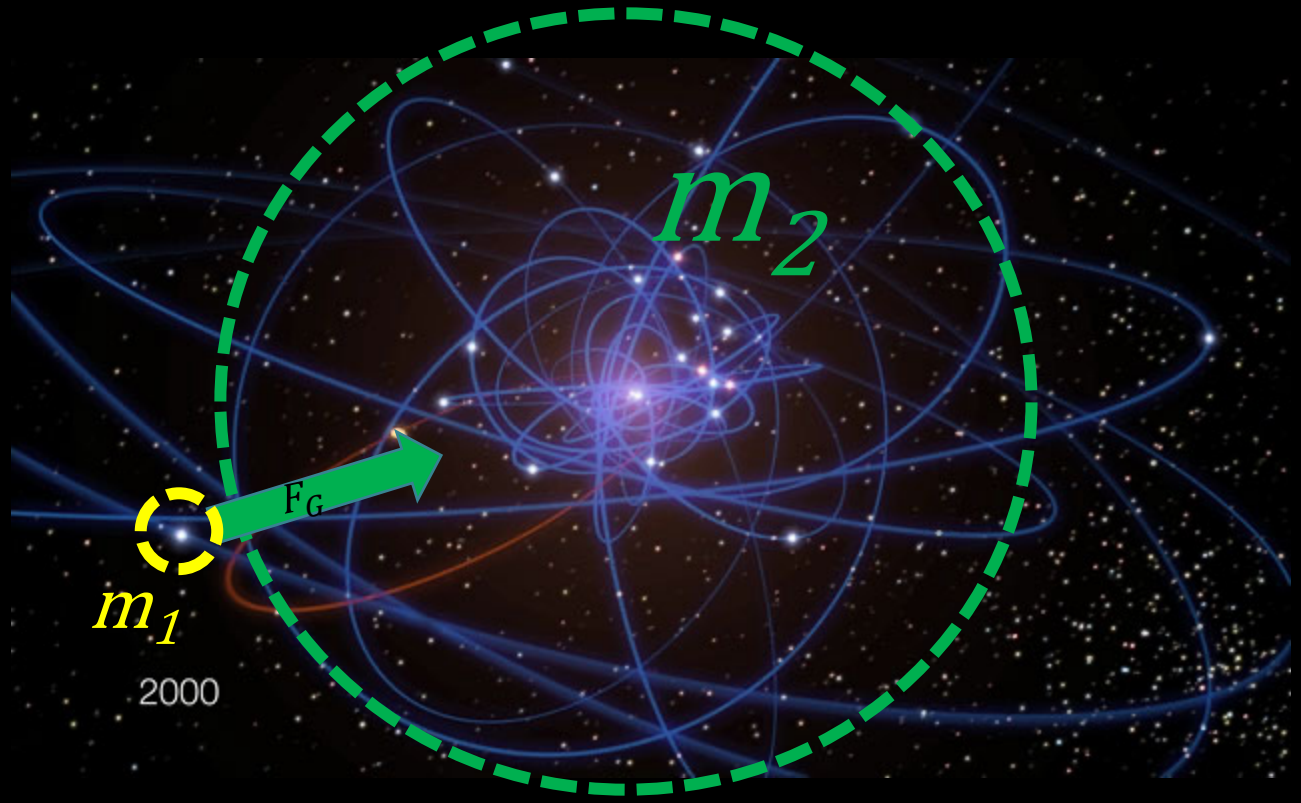
Amount of mass
Divided by distance

How fast its
motion changes



Dark Matter??

Dwarf Galaxies


m_2
F_G
m_1
2000

“What we know is a drop, what we don't know is an ocean.”
— Isaac Newton

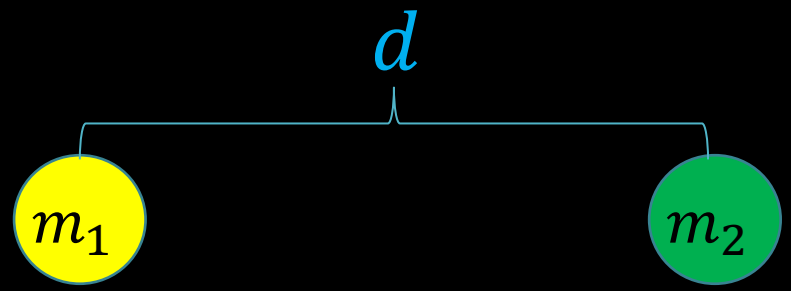
“I have no special talents. I am only passionately curious.” – Albert Einstein

Extra slides

Force of Gravity

$$F_G = G\frac{m_1 m_2}{d^2} = 1\frac{1 * 1}{1^2} = 1$$

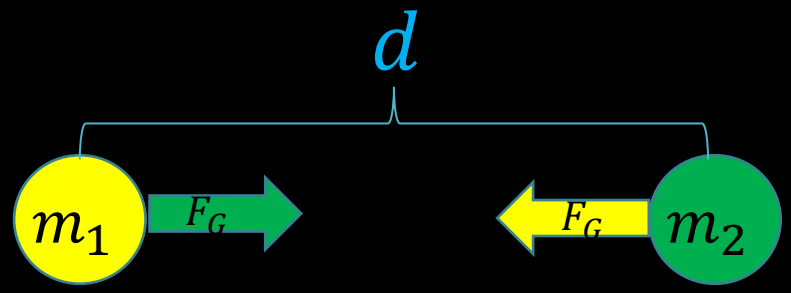
$G = 1$
$d = 1\ meter$
$m_1 = 1\ kilogram$
$m_2 = 1\ kilogram$



Force of Gravity

$$F_G = G\frac{m_1 m_2}{d^2} = 1\frac{1 * 1}{1^2} = 1$$

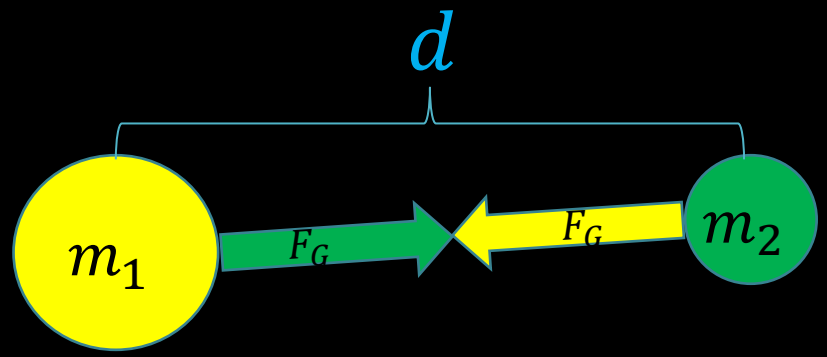
$G = 1$
$d = 1\ meter$
$m_1 = 1\ kilogram$
$m_2 = 1\ kilogram$



Force of Gravity

$$F_G = G\frac{m_1 m_2}{d^2} = 1\frac{2 * 1}{1^2} = 2$$

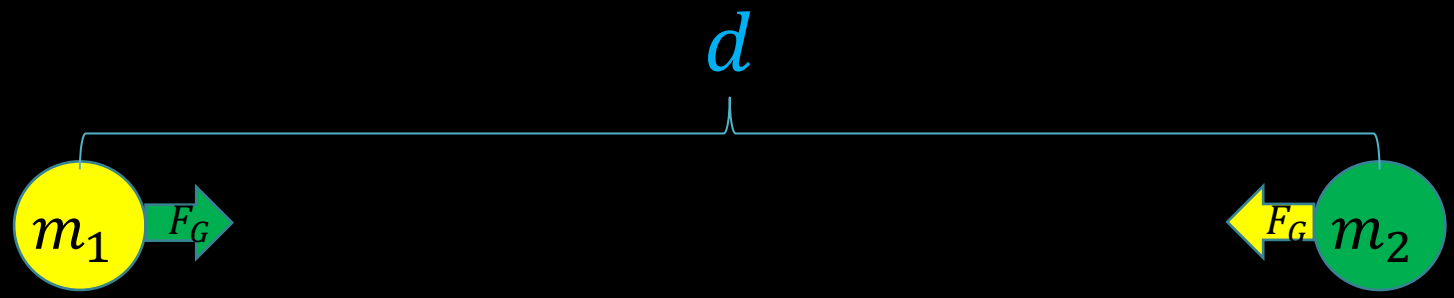
$d = 1\ meter$
$m_1 = 2\ kilograms$
$m_2 = 1\ kilogram$



Force of Gravity

$$F_G = G\frac{m_1 m_2}{d^2} = 1\frac{1 * 1}{2^2} = \frac{1}{4}$$

$d = 2\ meters$
$m_1 = 1\ kilogram$
$m_2 = 1\ kilogram$



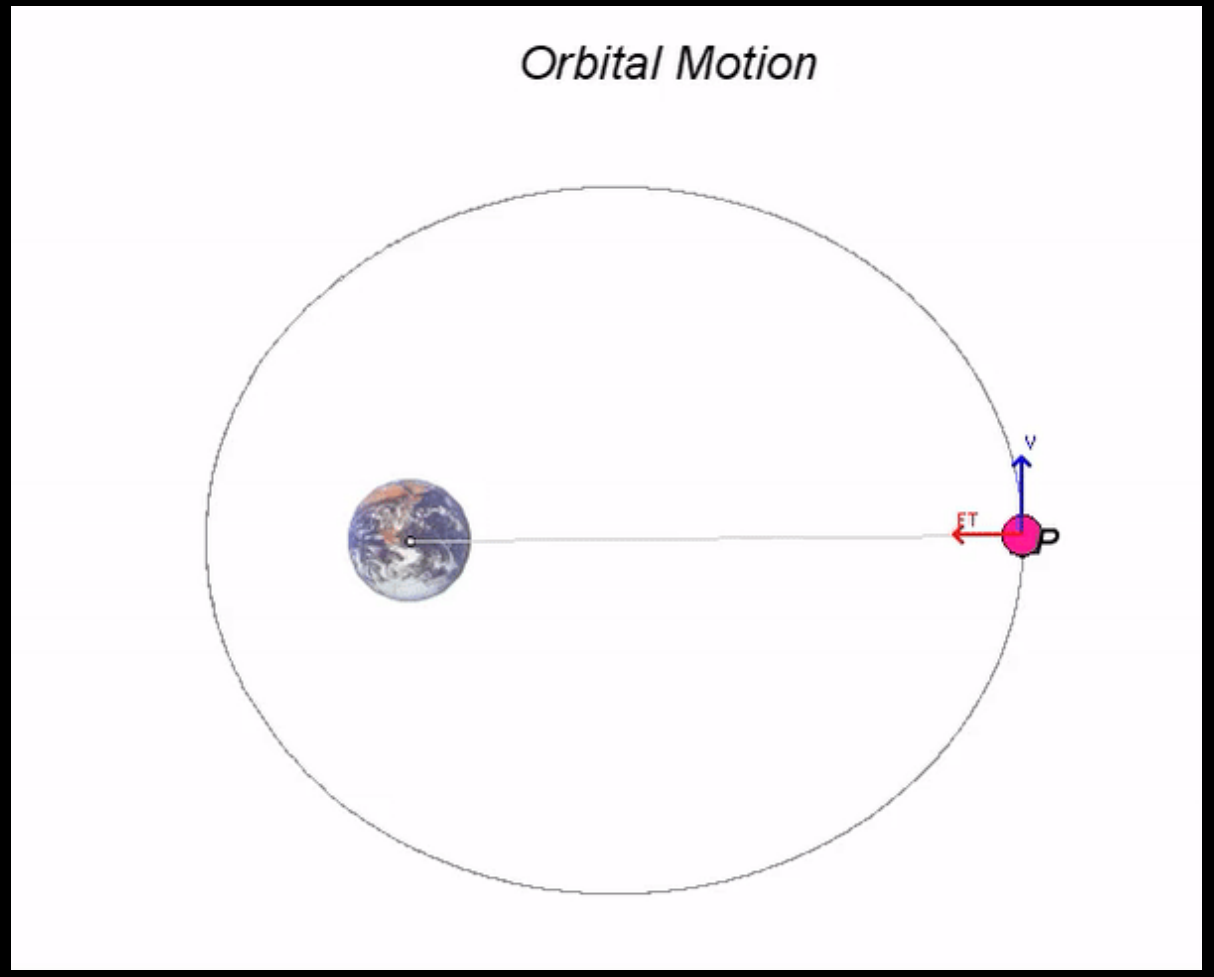
Force of Gravity

Newton's 3rd Law

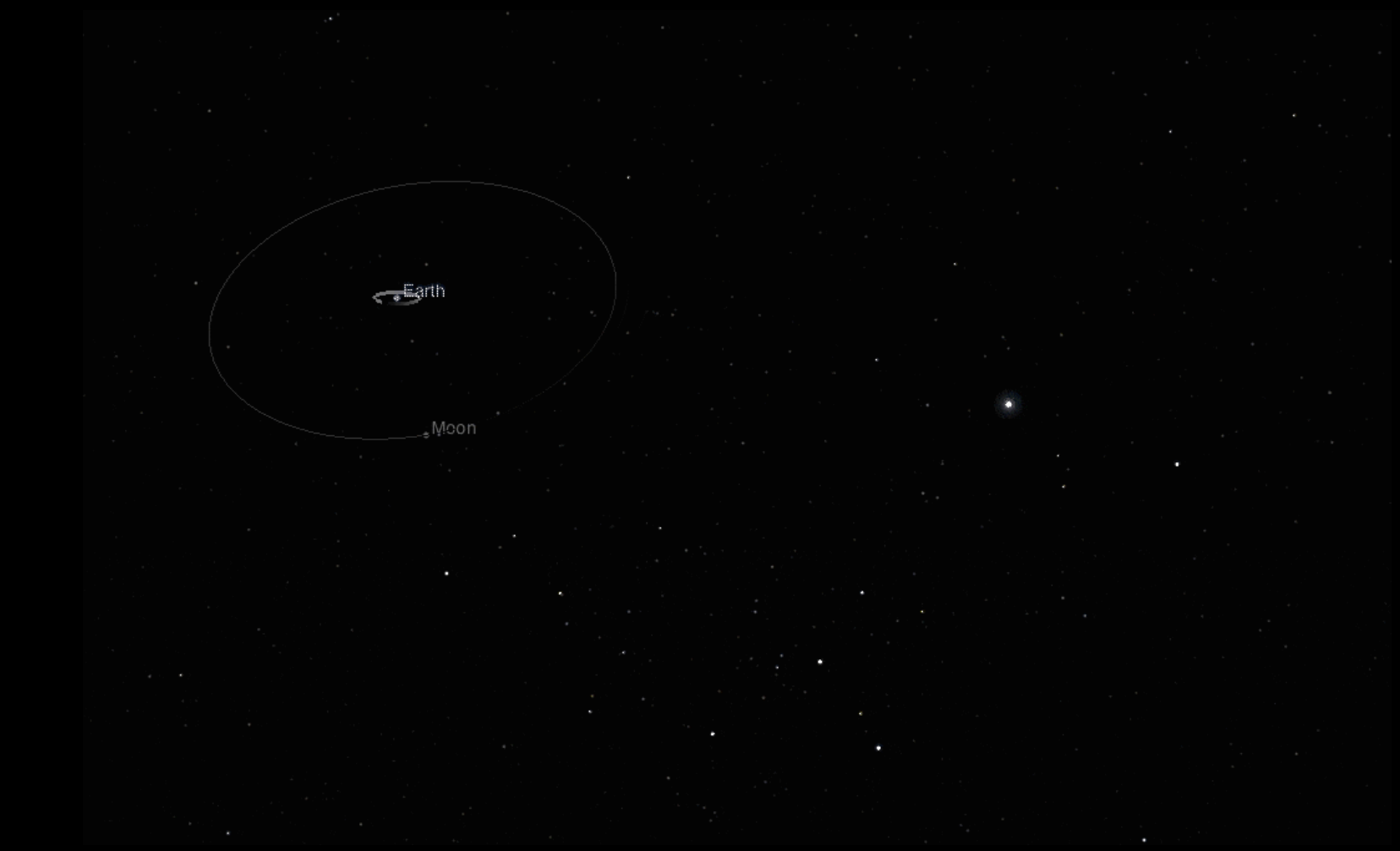
Force and motion

Newton's 2nd Law

$$F = ma$$

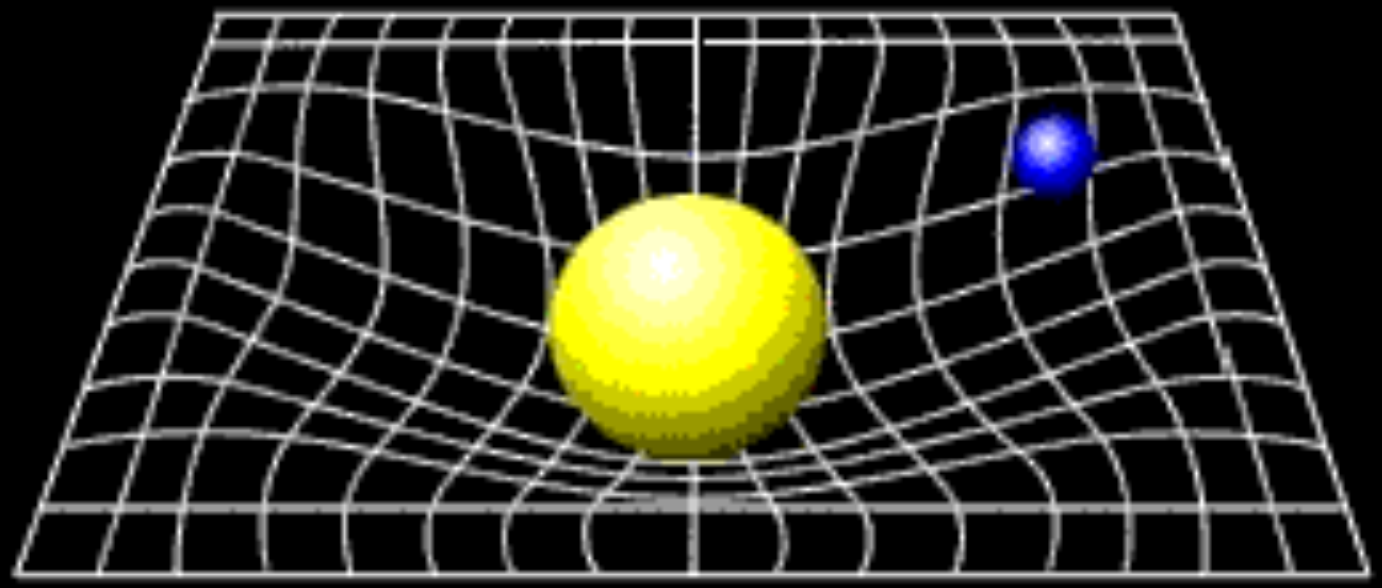


Newton's 1st Law



- An object at rest will stay at rest unless a force acts on it
- An object in motion will stay in motion unless a force acts on it

Gravity → General Relativity

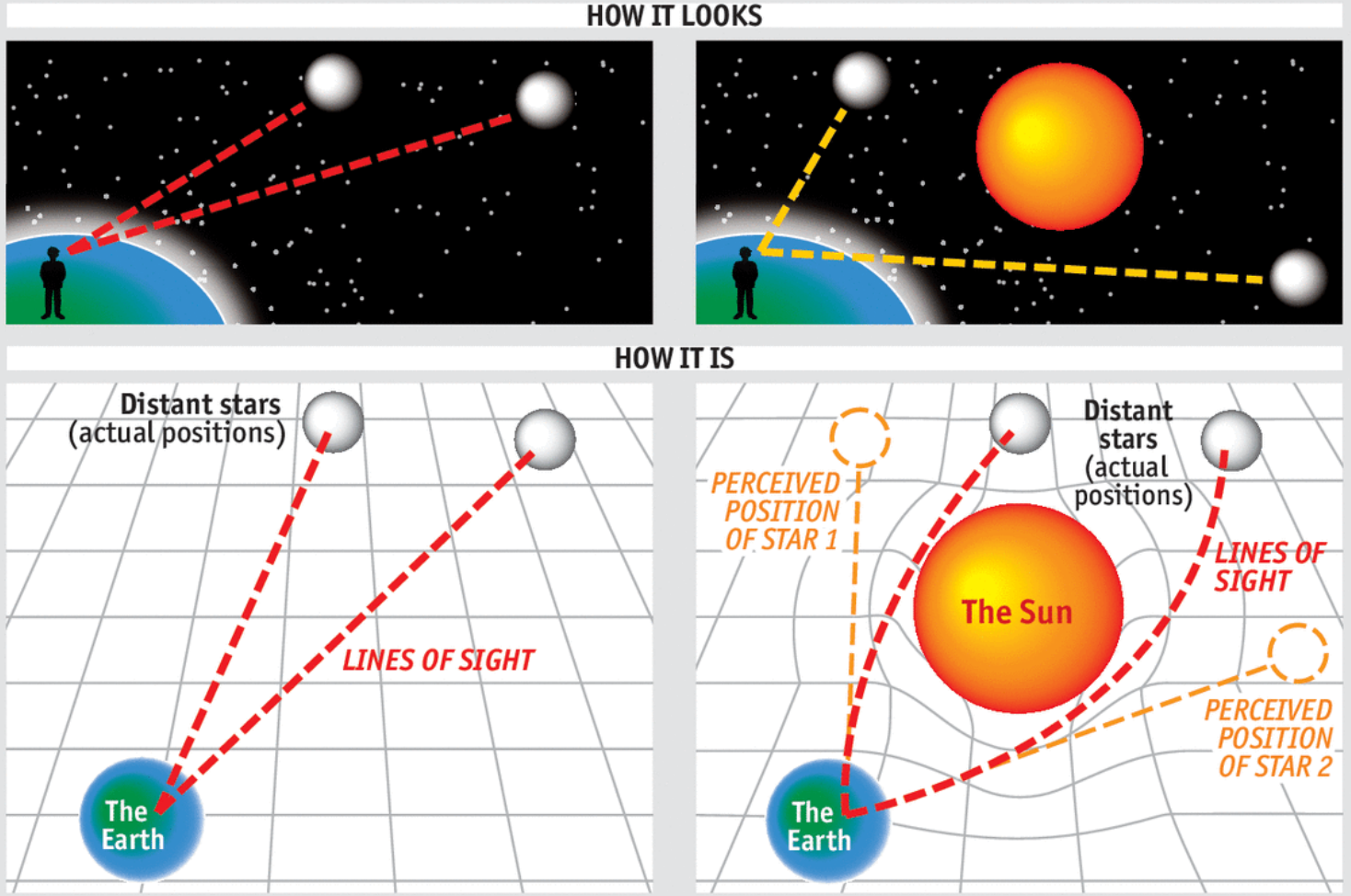


Gravitational Lenses

Gravitational Lenses

Lights all askew in the heavens

The intervening sun changes the way the sky appears by bending space-time



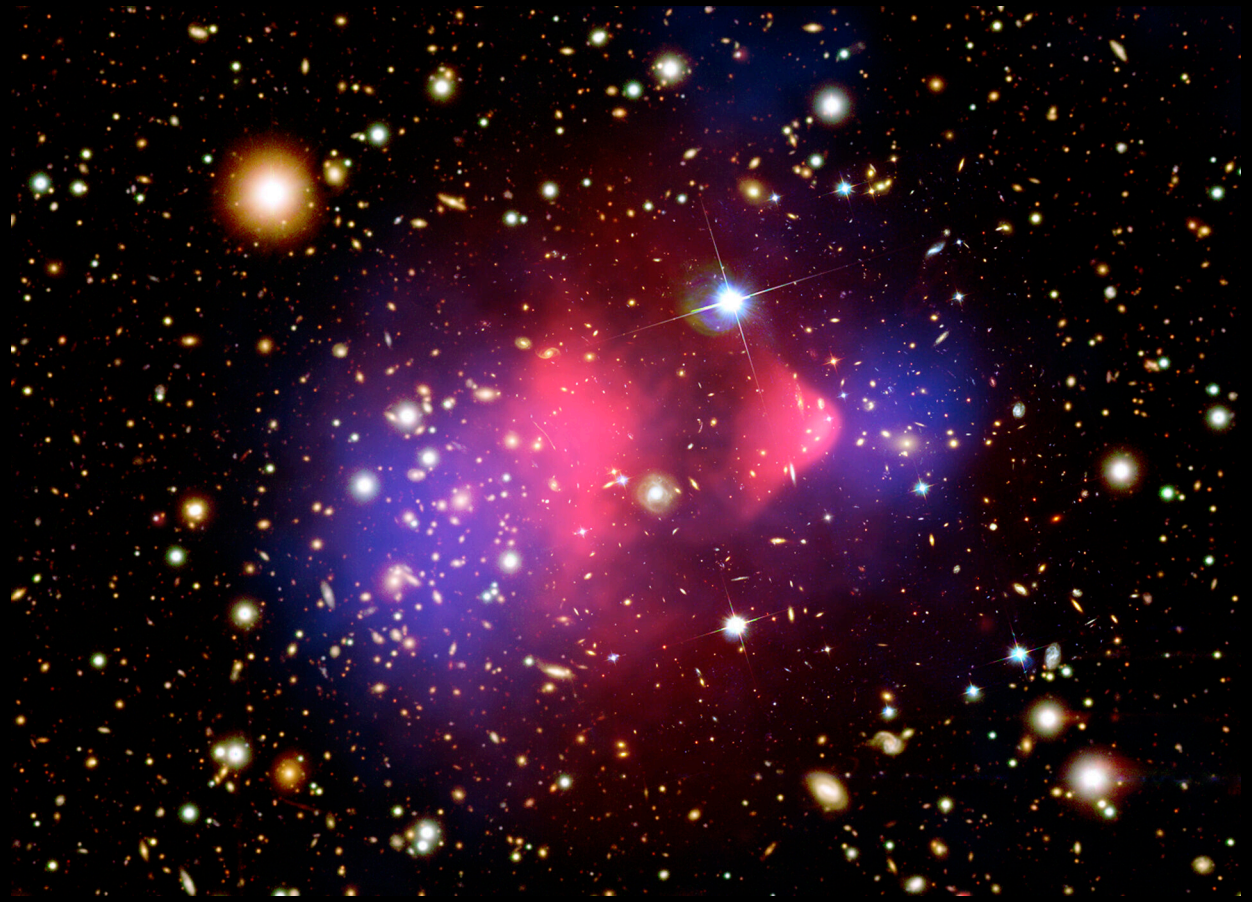
Source: Albert Einstein

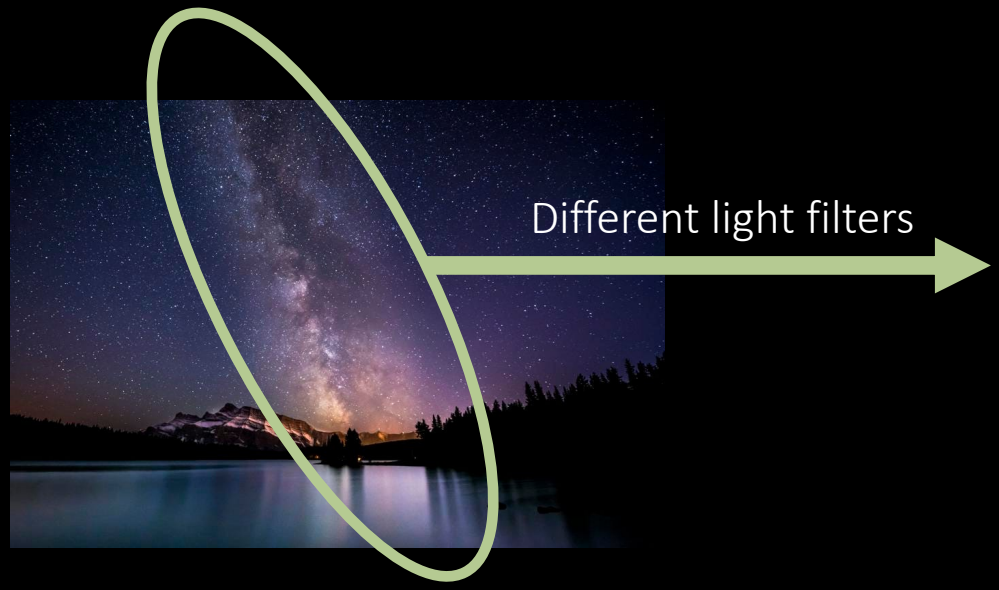
Economist.com

https://phet.colorado.edu/sims/html/gravity-and-orbits/latest/gravity-and-orbits_en.html

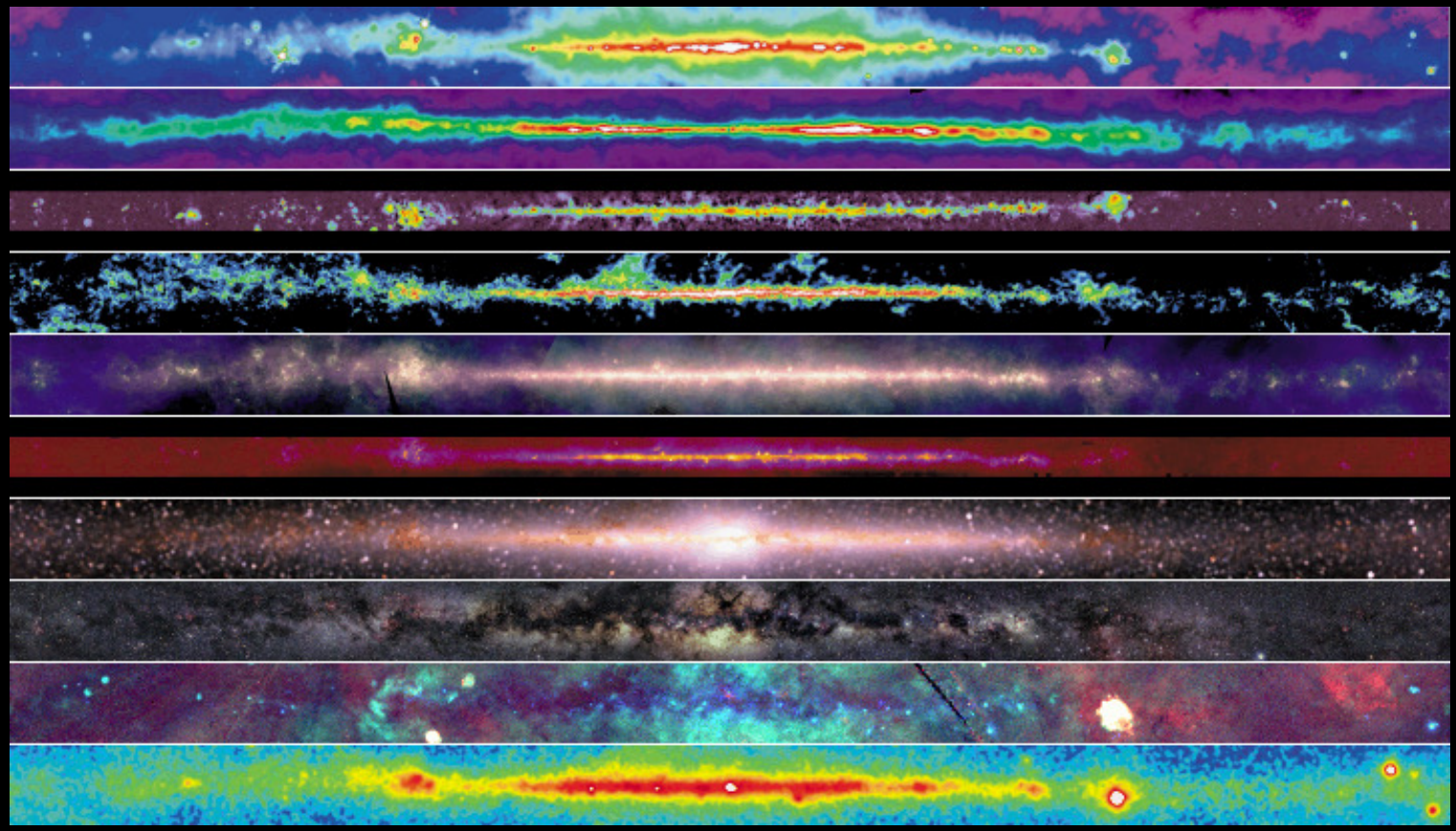
https://phet.colorado.edu/sims/html/gravity-force-lab-basics/latest/gravity-force-lab-basics_en.html

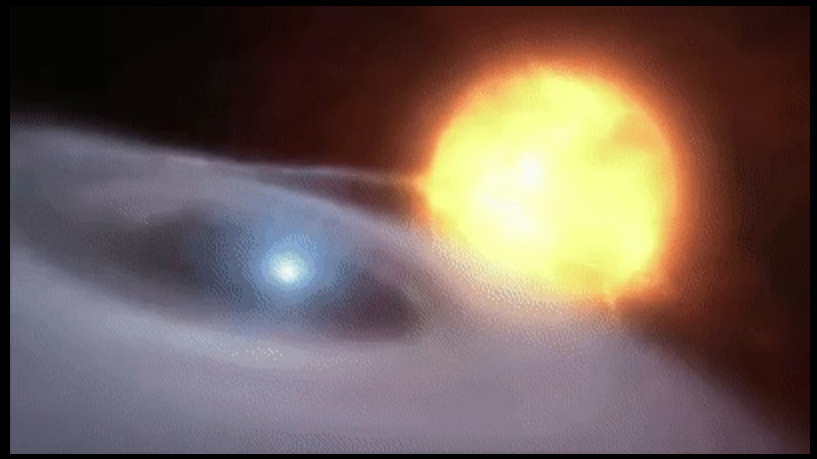
https://phet.colorado.edu/sims/html/my-solar-system/latest/my-solar-system_en.html





Different light filters





Heliocentrism

Geocentrism