Tuesday, 6 Feb

brought to you by the letters G R A V I T A T I O N

housekeeping

Wiki…I approve requests in bulk

Your mandatory book: Period 1:

Any time, but before 5 pm on January 26 enter the book that you've chosen into the appropriate Wiki page. Make a page in the Wiki for your review as per the instructions. (You can do this earlier!)

ISP220 Journalists: can we talk after class?

During Part 1:

I sure hope you're keeping up

More http server issues… keep me informed when it's not available

we have to fix it. a kludge installed now

this week:

9. gravitation

10. electric charge and magnetism

(next week’s Tuesday topics)

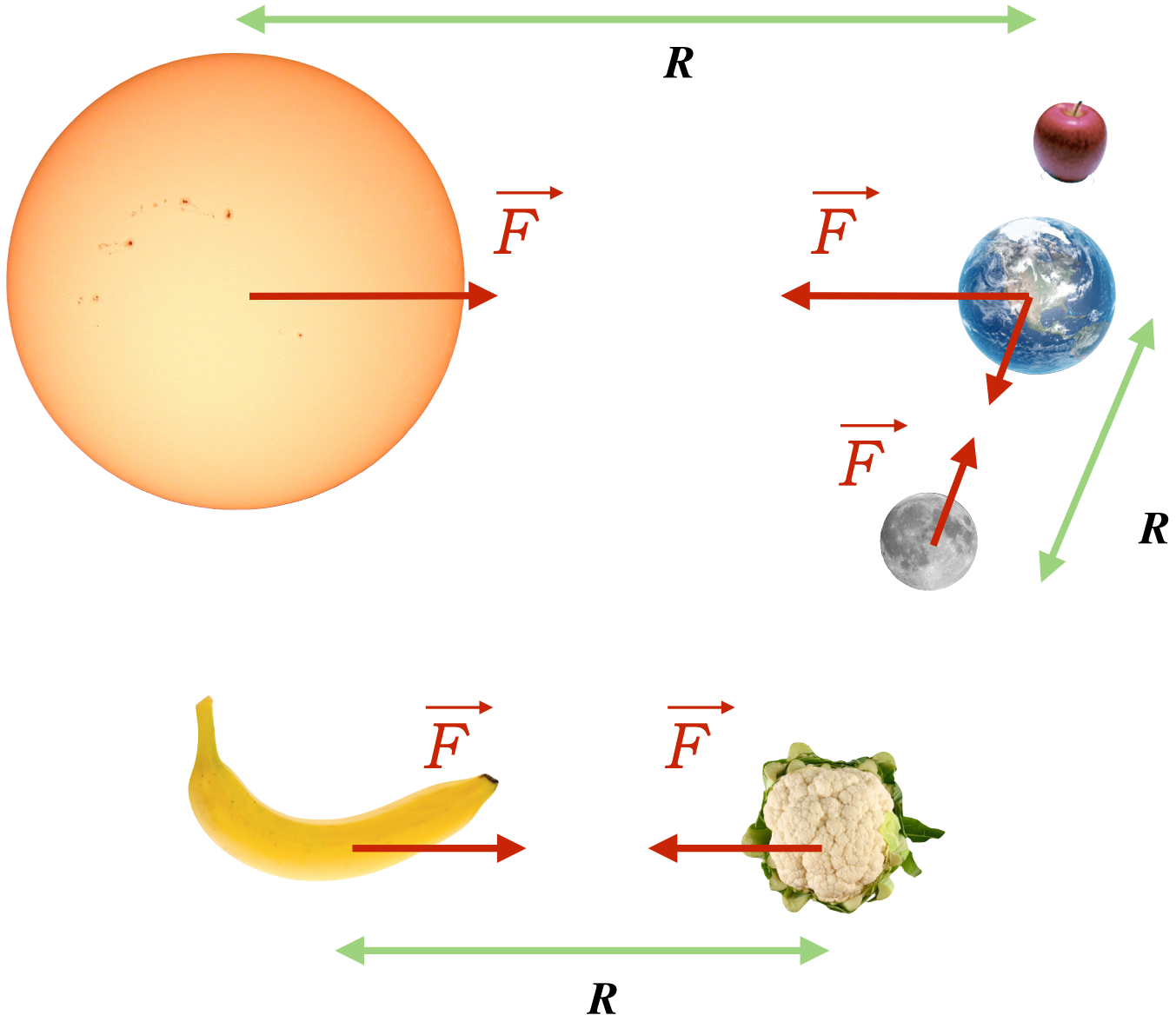
available Wednesday night:

11. Faraday’s Fields

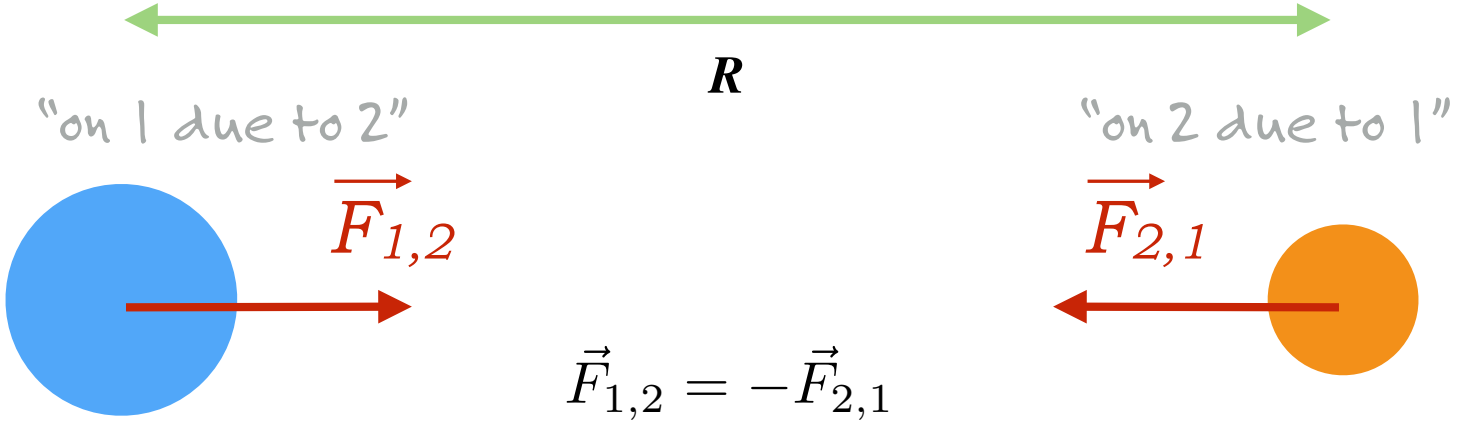
12. Maxwell’s Fields

this changed everything

One thing: Newton's Universal law of Gravitation



this changed everything



$$\vec{F}_{1,2} = -\vec{F}_{2,1}$$

$$|\vec{F}_{1,2}| = |\vec{F}_{2,1}| = F$$

$$F = G\frac{m_1 m_2}{R^2}$$

$G = 6.67300 \times 10^{-11}\ \mathrm{m^3\ kg^{-1}\ s^{-2}}$

"Gravitational Constant"

follow-on to Newton

impact changed western civilization

no lie.

Newton’s telescope design

many solar-system discoveries

original 6 objects: Mercury, Venus, Earth, Moon, Mars, Jupiter, Saturn

17th century: 4 Jupiter moons, 5 Saturn moons

18th century: Uranus, 2 Uranus moons, 2 more Saturn moons

19th century: Neptune, 1 Neptune moon, 2 more Saturn moons, 2 Mars moons, 1 Jupiter moon

20th century: 12 more Jupiter moons, 7 Neptune moons, Pluto, 12 more Saturn moons, 16 Uranus moons

21st century: 35 more Saturn moons, 35 more Jupiter moons, 7 more Neptune moons, 4 Pluto moons, 7 more Uranus moons, plus a brand new planet (last week)?

+ >2000 exoplanets

predictions and confirmations galore

Resistive media

tides (moon and earth)

oblateness of the earth (if it rotates)

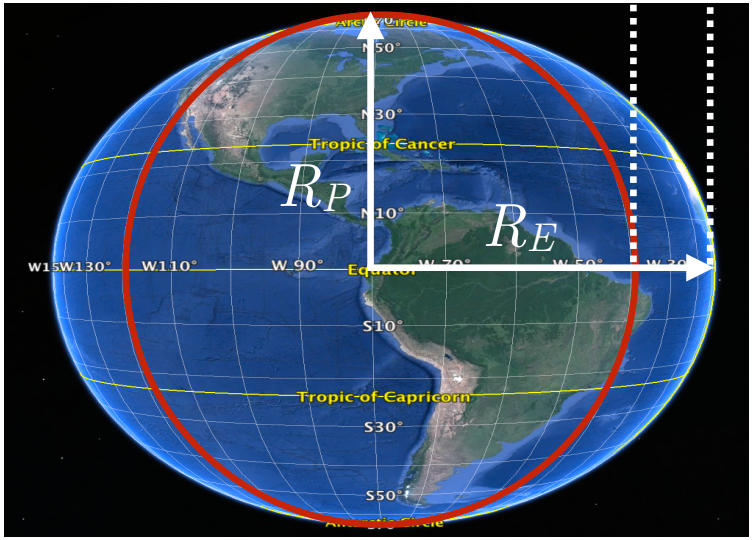
little g different at equator than north or south

1 degree longitude measured in Lapland by Pierre de Maupertius in 1736

"precession of the equinoxes" because of top-like wobbling of the earth's axis

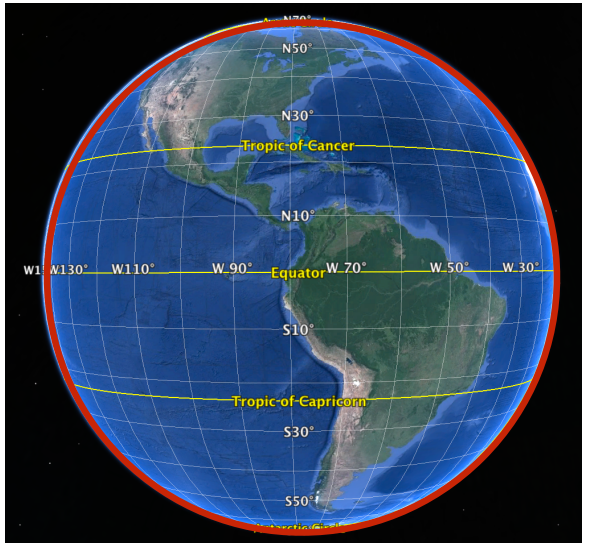
method to determine the path of a comet with 3 measurements

$R_E - R_P \sim 13$ miles



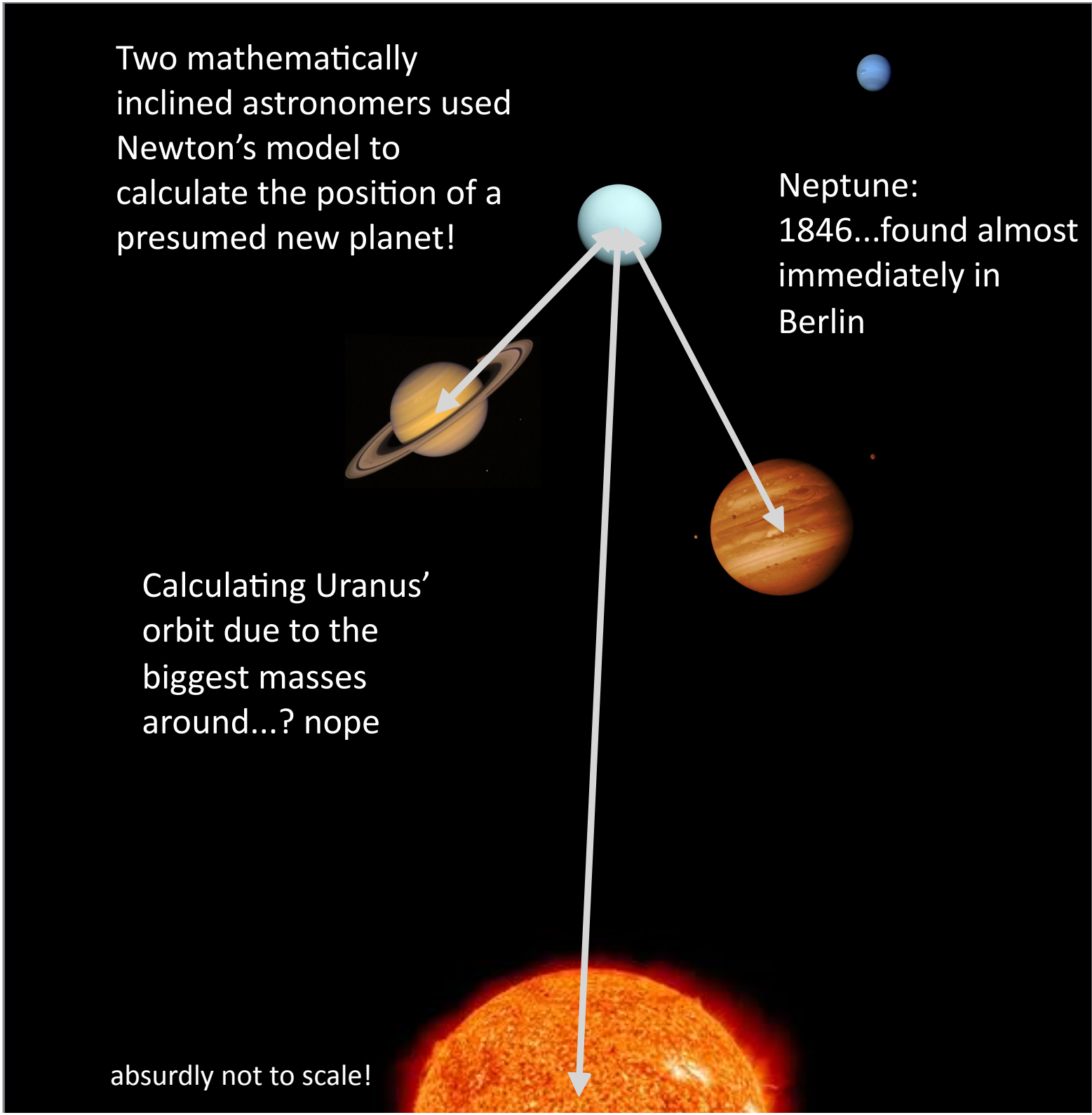
N: $R_E = (231/230)R_P$

(now 301/300)



from a theory to a rule

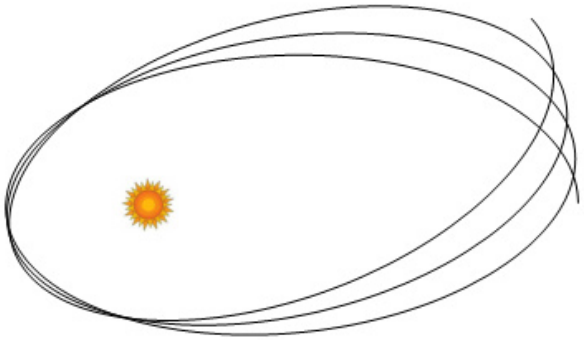
by 1840, it was clear that something was wrong with the orbit of Uranus



Mercury’s orbit is weird

Vulcan?

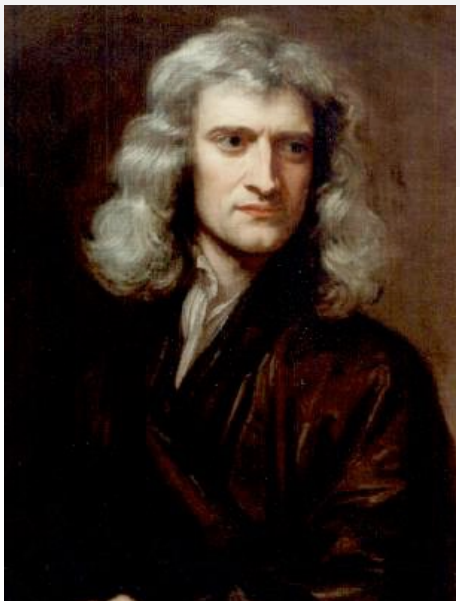
nope

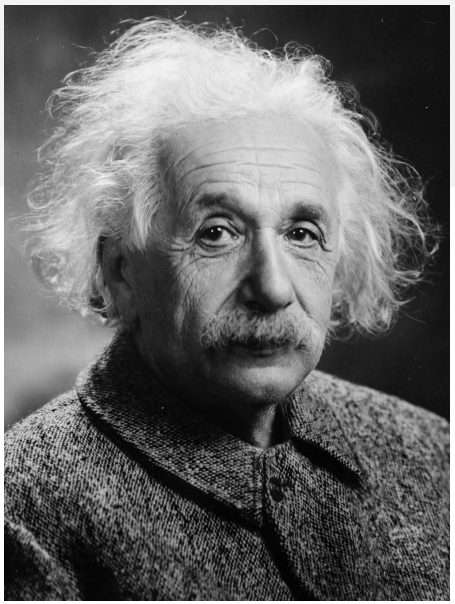


okay.

There’s only been one other person in the history of physics as revolutionary as Isaac Newton

mercury plays a role





one manipulation…and our project

T-shirt equation:

$$F_{1,2} = m_1 a$$

for a circular path:

$$a = \frac{v^2}{R}$$

Gravitation:

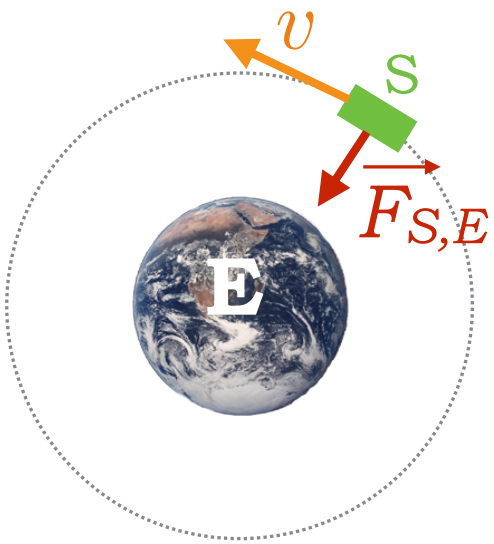
$$F_{1,2} = G\frac{m_1 m_2}{R^2}$$

put them together:

any gravitationally-bound object

say a satellite (S) orbiting the earth (E)

$$F_{S,E} = G\frac{M_E M_S}{R^2}$$



$$G\frac{M_S M_E}{R^2} = M_S\frac{v^2}{R}$$

$$G\frac{M_S M_E}{R^2} \times R = M_S\frac{v^2}{R} \times R$$

$$v^2 = G\frac{M_E}{R}$$

$$v = \sqrt{G\frac{M_E}{R}}$$

answer, defend

Force on satellite due to earth:

$$F_{S,E} = G\frac{M_E M_S}{R^2}$$

$$v^2 = G\frac{M_E}{R}$$

as the distance goes up,
the speed:

A increases

B stays the same

C decreases

D

answer, defend

Force on satellite due to earth:

$$F_{S,E} = G\frac{M_E M_S}{R^2}$$

$$v^2 = G\frac{M_E}{R}$$

as the speed goes up,
the distance:

A increases

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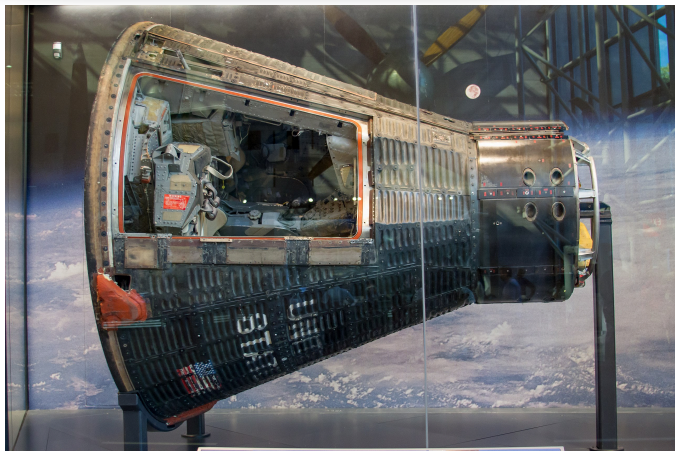
D

now go back to yesteryear of NASA

DOCKING!!

$$v^2 = G\frac{M_E}{R}$$



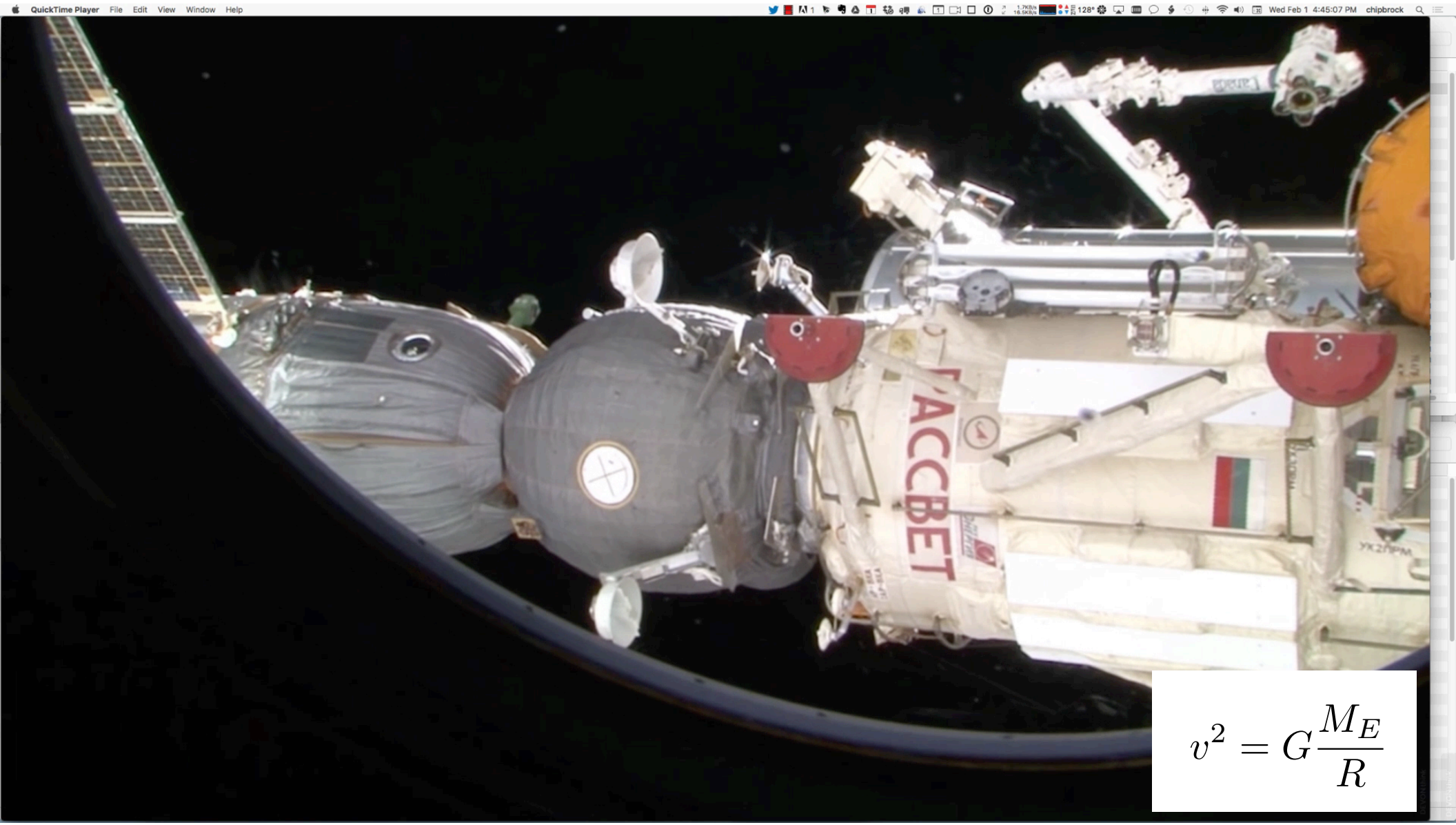
Gemini V

June 1965

James McDivitt and Ed White

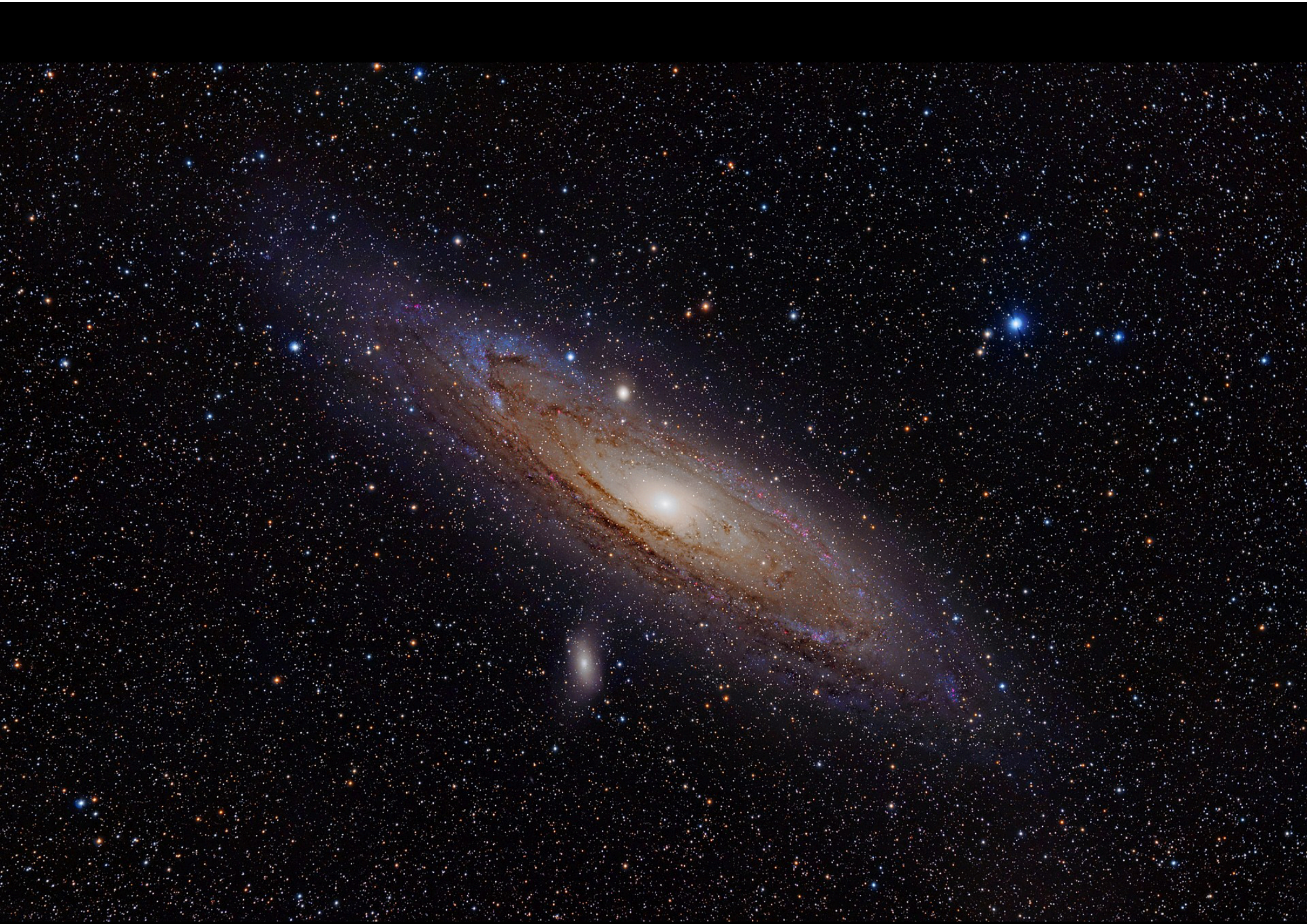
quiz

docking…strange: “Hohmann Transfer”: 2 days



$$v^2 = G\frac{M_E}{R}$$

now one of the 2 biggest problems in all of physics and astronomy



Andromeda Galaxy, aka M31

something is terribly wrong

with stellar and galactic motions

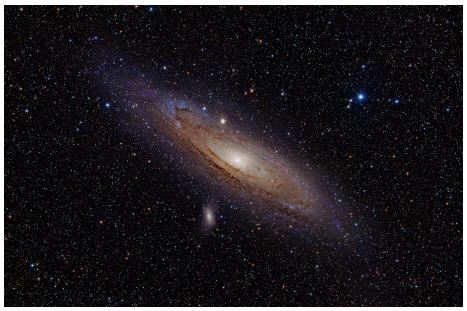
Coma cluster of galaxies

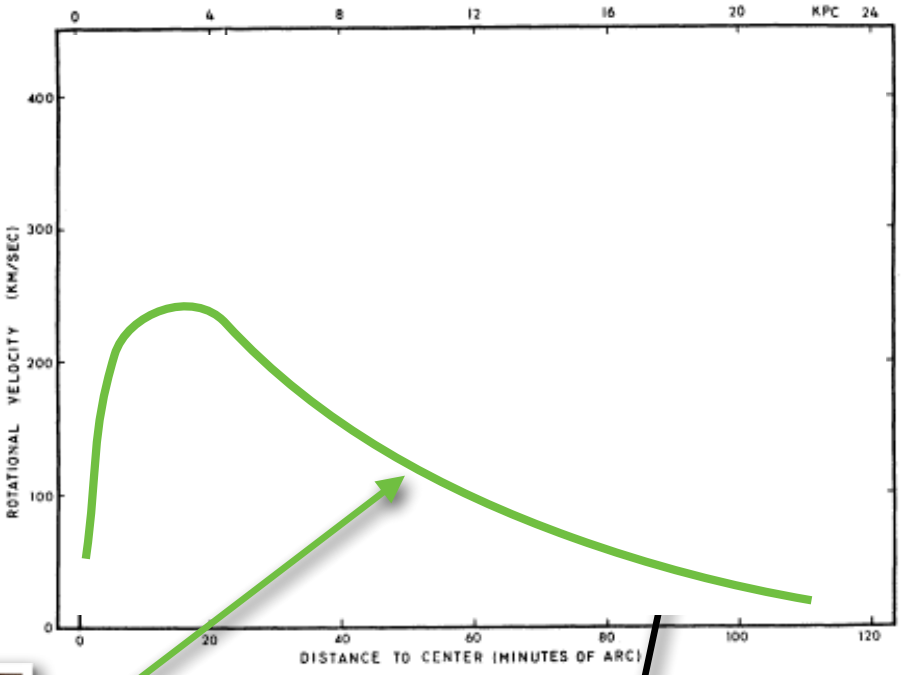
Fritz Zwicky, 1933

something's there

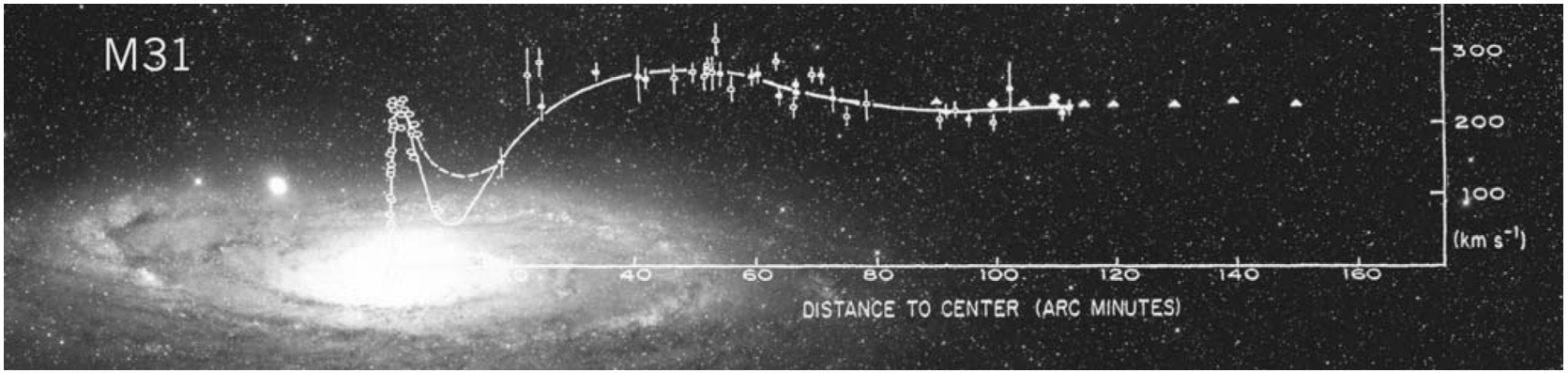
$$v = \sqrt{G\frac{M_{\text{galaxy center}}}{R}}$$

Vera Rubin, w/ Kent Ford,
1970: Andromeda





too
fast!



Something's wrong! The amount of mass required in order to match the motion is about 1/6 of what is observable.

TWO DISC 20TH ANNIVERSARY EDITION
LLOYD KAUFMAN AND MICHAEL HERZ PRESENT A TROMA TEAM RELEASE
THERE'S NOTHING OUT THERE!
A ROLFE KANEFSKY FLICK
"NOTHING has a lot going for it!"
Los Angeles Times

it’s darker than you think

something is out there

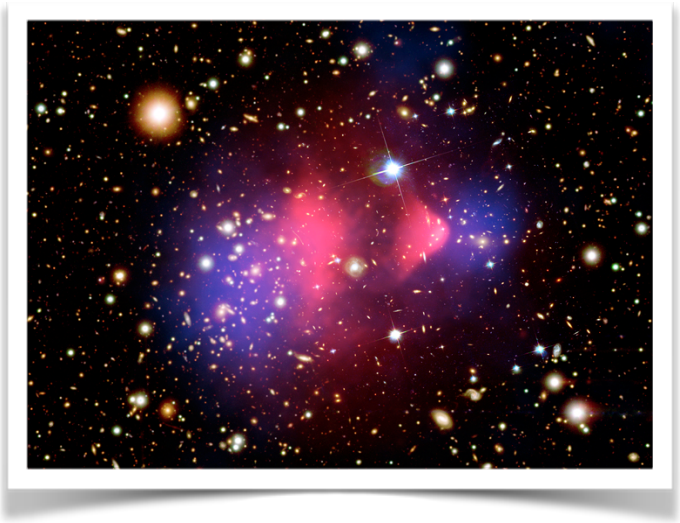
it doesn't shine

visible light, X-rays, Infrared, UV...nothing.

so it's not regular atoms

But. It gravitates.

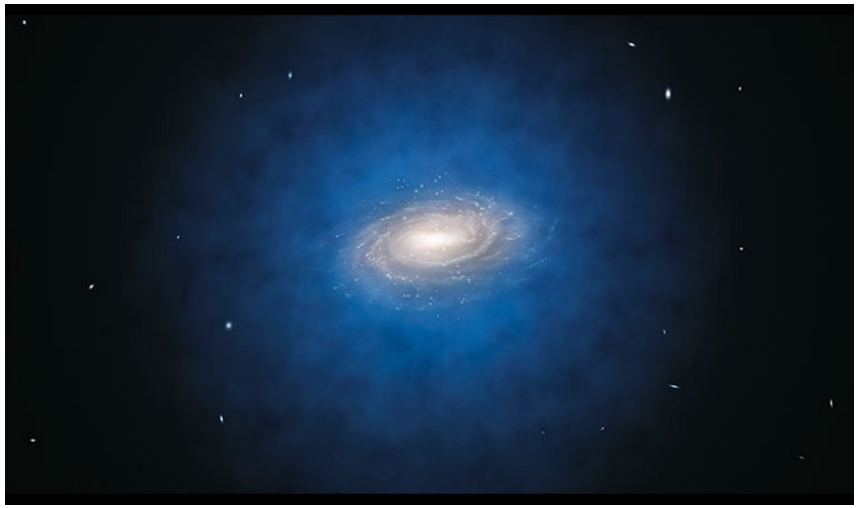
silver bullet(s)



Bullet Cluster

Abel 1689 composite image from Hubble Space Telescope and the Chandra X-ray Observatory

simulation-inspired artistic view of milky way…blue is the amount of dark matter required



https://www.youtube.com/watch?v=mRtGUCljQ3w

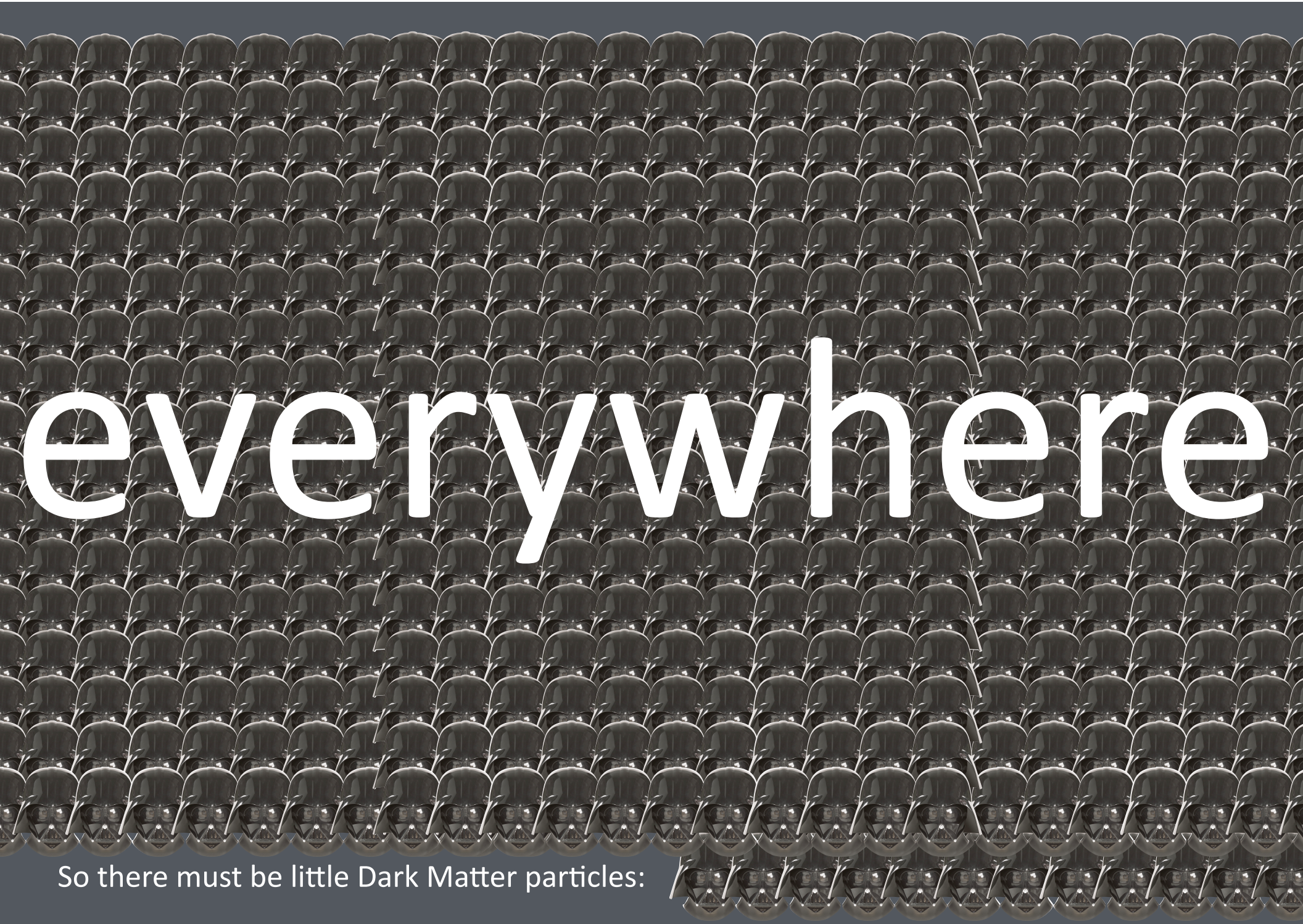
Simulation...

if it’s not a particle

then, we’re completely lost

which would be…you know…kind of cool

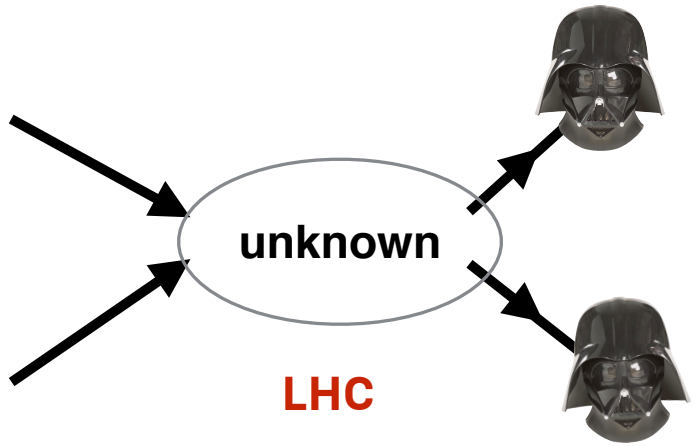
DARK
MATTER


everywhere
So there must be little Dark Matter particles:

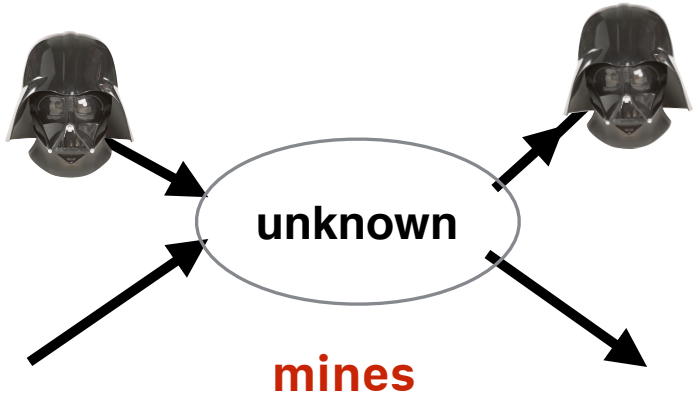
experiments

on the Earth, in orbit, and deep under the Earth's surface

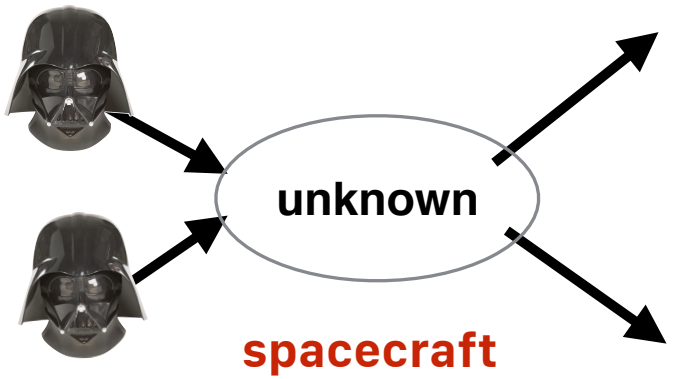
production



direct detection



indirect detection



hypothetical

Dark Matter

=:-o

? - but perhaps 30% of the universe

?

something entirely new

projects

$$v = \sqrt{G \frac{M_{\text{center}}}{R}}$$