Today's Topics

Friday, January 23, 2026 (Week 0, lecture 2) – Chapters 1 & 2.

A. Distances using the speed of light

B. Scientific notation … Exponents review

C. Length scales in the universe

D. Trigonometry review (see worked problem)

E. Ancient Greek physics: radius of the Earth

Distances with the Speed of Light

Circumference of the Earth = 0.13 s = 130 milliseconds

OpenStax; R. Stockli, A. Nelson, F. Hasler, NASA/GSFC/NOAA/USGS)

Distances with the Speed of Light

Earth – Moon distance = 1.3 s

Earth and Moon, Drawn to Scale. [OpenStax; NASA]

Distances with the Speed of Light

Sun – Earth distance = 499 s ≈ 8.3 minutes

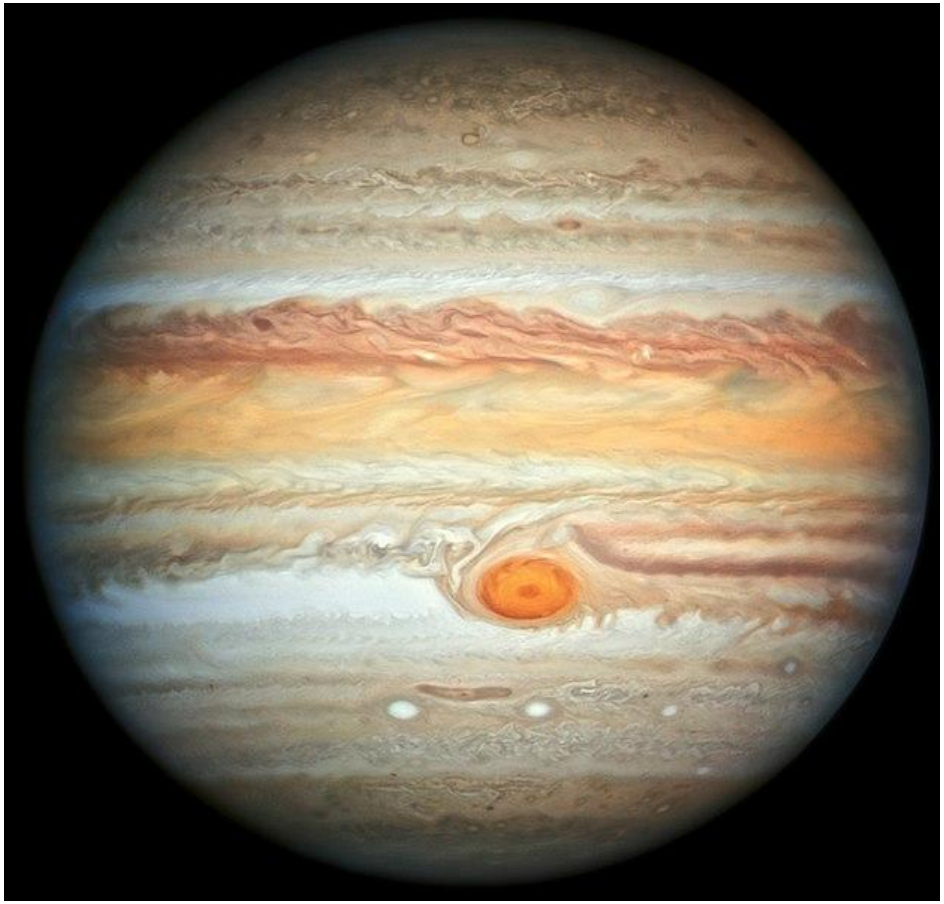
= 149,597,870,700 m ≈ 150×10^6 km

= 1 Astronomical Unit = 1 AU

Earth and Sun seen from International Space Station [Wikipedia, NASA]

Distances with the Speed of Light

Sun – Jupiter distance ≈ 43 light minutes



Jupiter viewed by Hubble telescope [Wikipedia, NASA]

Distances with the Speed of Light

Sun – Pluto distance ≈ 5.5 light hours

Distances with the Speed of Light

Sun to nearest star* (Alpha Centauri) = 4.3 years = 4.3 ly (light years)

Scientific Notation

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Shorthand notation for very large and very small numbers.

"3.57 times ten to the power of eight"
= 357,000,000
= 3.57×10^8
= 357×10^6
=3.57*10^8
= 3.57e8 = 3.57e+8 useful for computers

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"3.57 times ten to the power of minus five"
= 0.0000357
= 3.57×10^{-5}
= 357×10^{-7}
=3.57*10^(-5)
= 3.57e-5

Scientific Units -- Prefixes

Bigger

10^{1} = deca (da)

10^{2} = hecto (h)

10^{3} = kilo (k) = thousand

10^{6} = mega (M) = million

10^{9} = giga (G) = billion

10^{12} = tera (T) = trillion

10^{15} = peta (P)

10^{18} = exa (E)

10^{21} = zetta (Z)

10^{24} = yotta (Y)

Scientific Units -- Prefixes

Smaller

10^{-1} = deci (d)

10^{-2} = centi (c) = 1/100th

10^{-3} = milli (m) = 1/1000th

10^{-6} = micro (μ) = millionth

10^{-9} = nano (n) = billionth

10^{-12} = pico (p) = trillionth

10^{-15} = femto (f)

10^{-18} = atto (a)

10^{-21} = zepto (z)

10^{-24} = yocto (y)

Bigger

10^{1} = deca (da)

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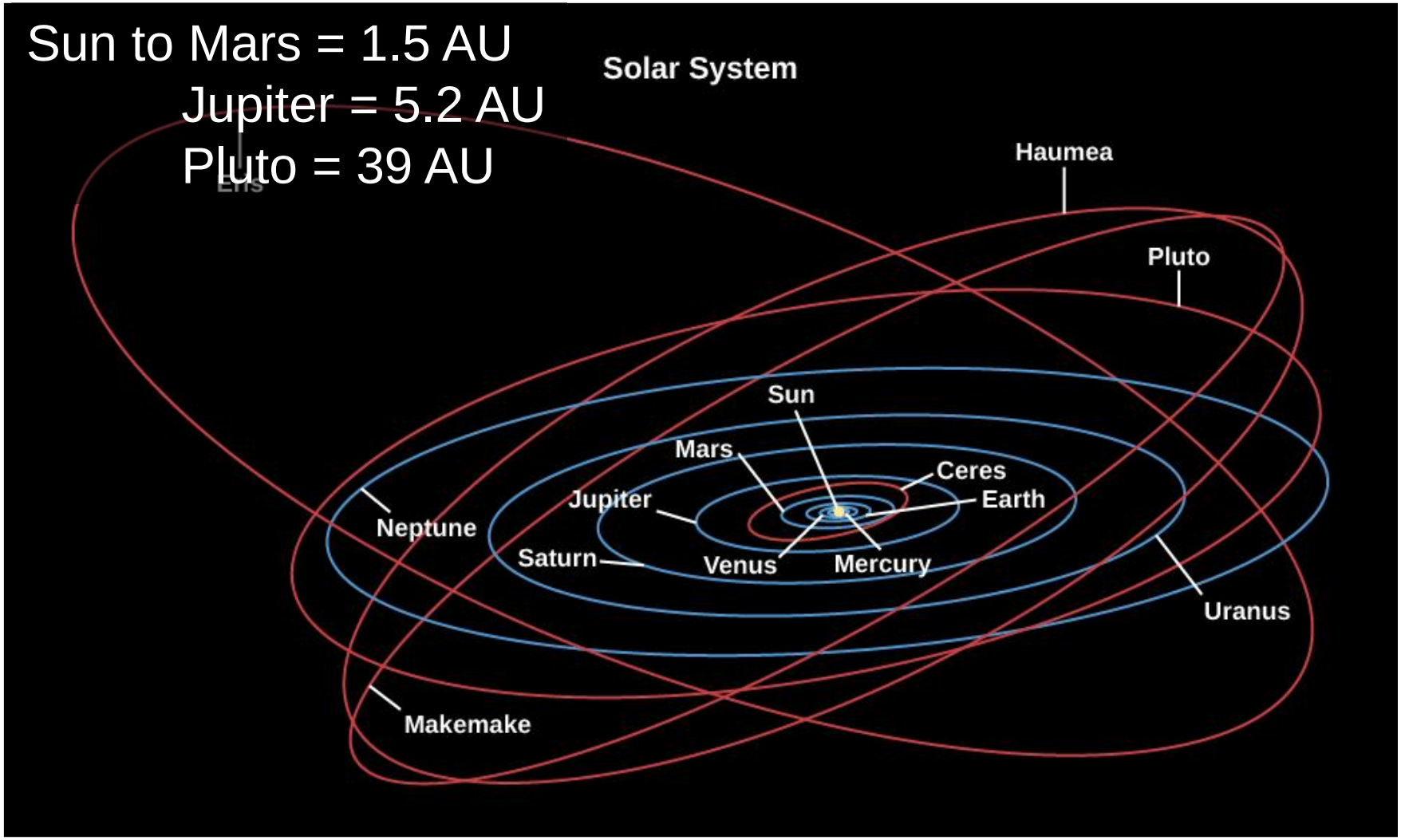
Length Scales in the Universe

Solar System Scale

Reminder: Sun-to-Earth = 1 AU



[OpenStax: Astronomy]

Solar System Scale

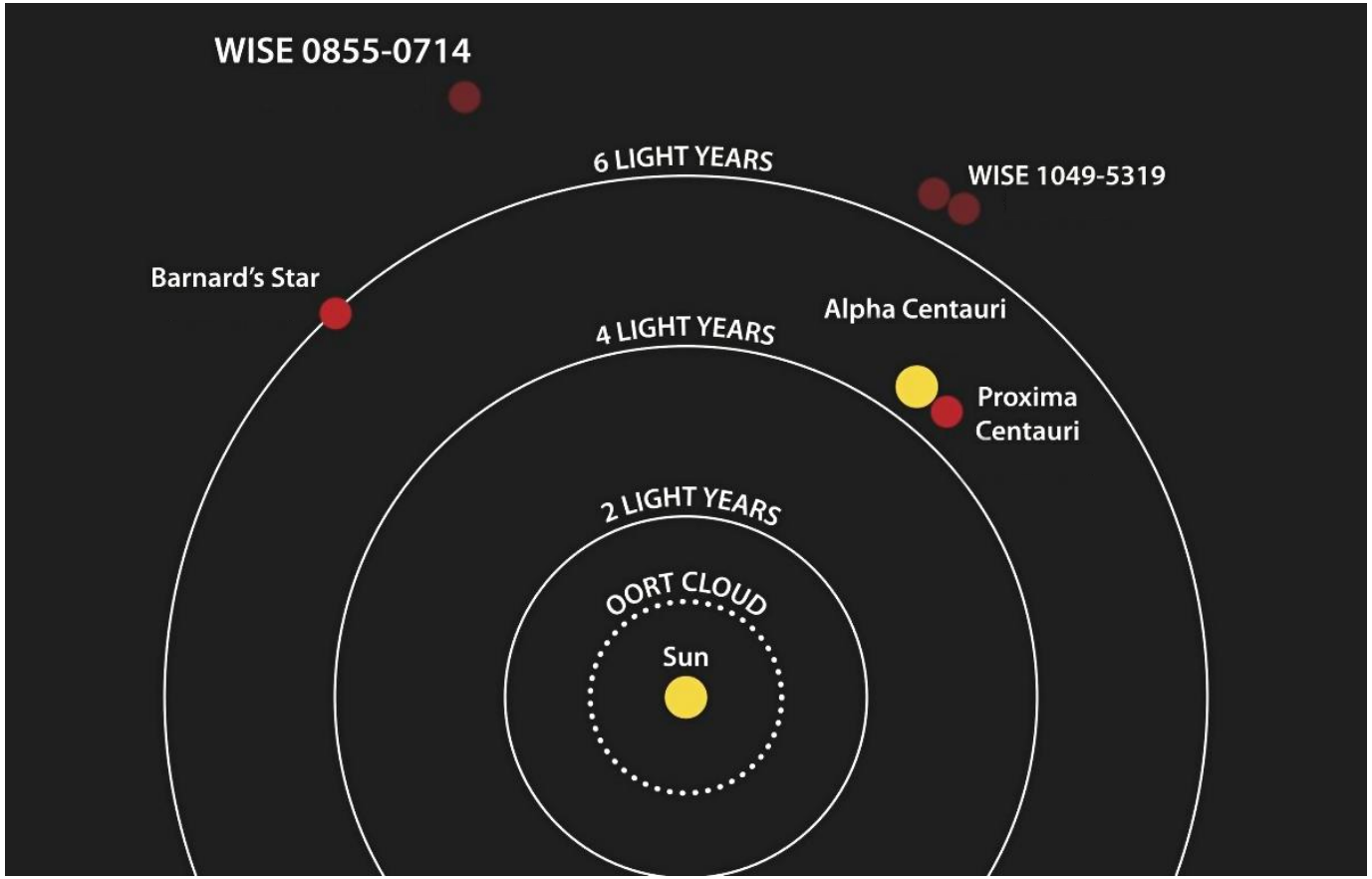
Relative size of planets & Sun

- diameter of Sun ≈ 109 Earths
- diameter of Jupiter ≈ 22 Earths

[OpenStax; NASA]

Nearby Stars Scale ~ 7 light years

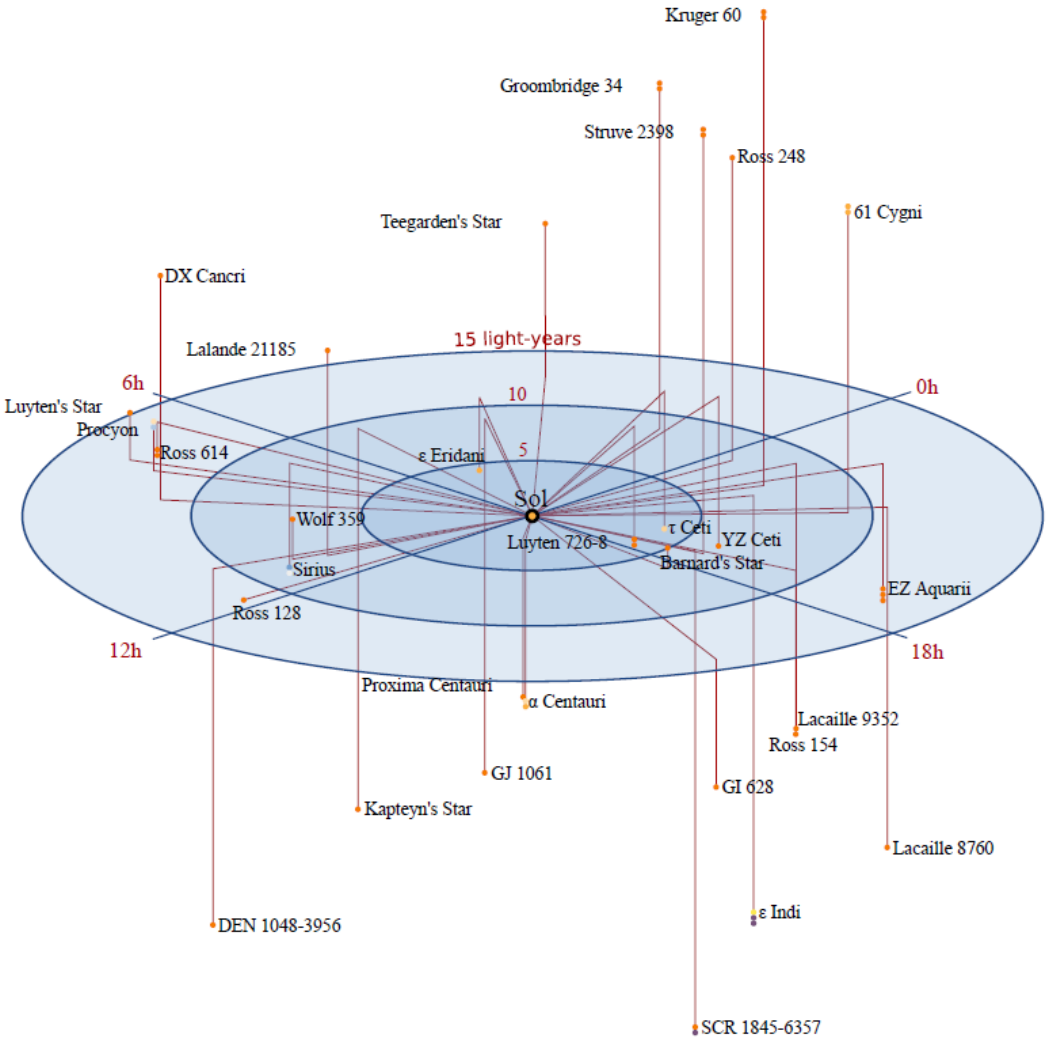
7 nearby stars



[Wikipedia; NASA, Penn State University]

Nearby Stars Scale ~ 15 light years

Several dozen stars in our stellar neighborhood

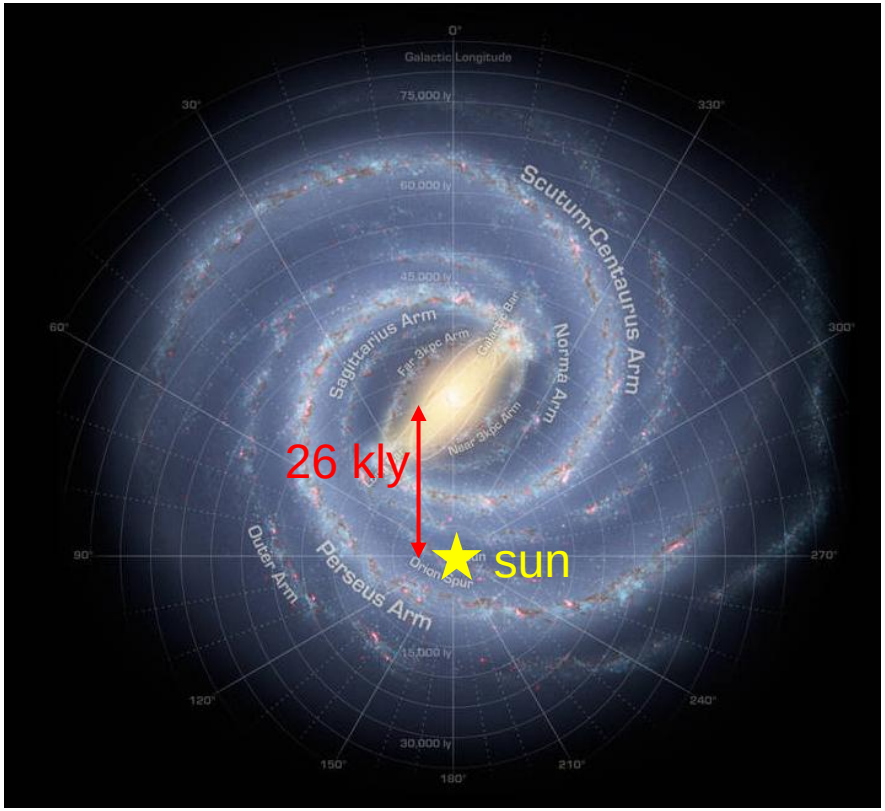


[Wikipedia]

Milky Way Galaxy Scale

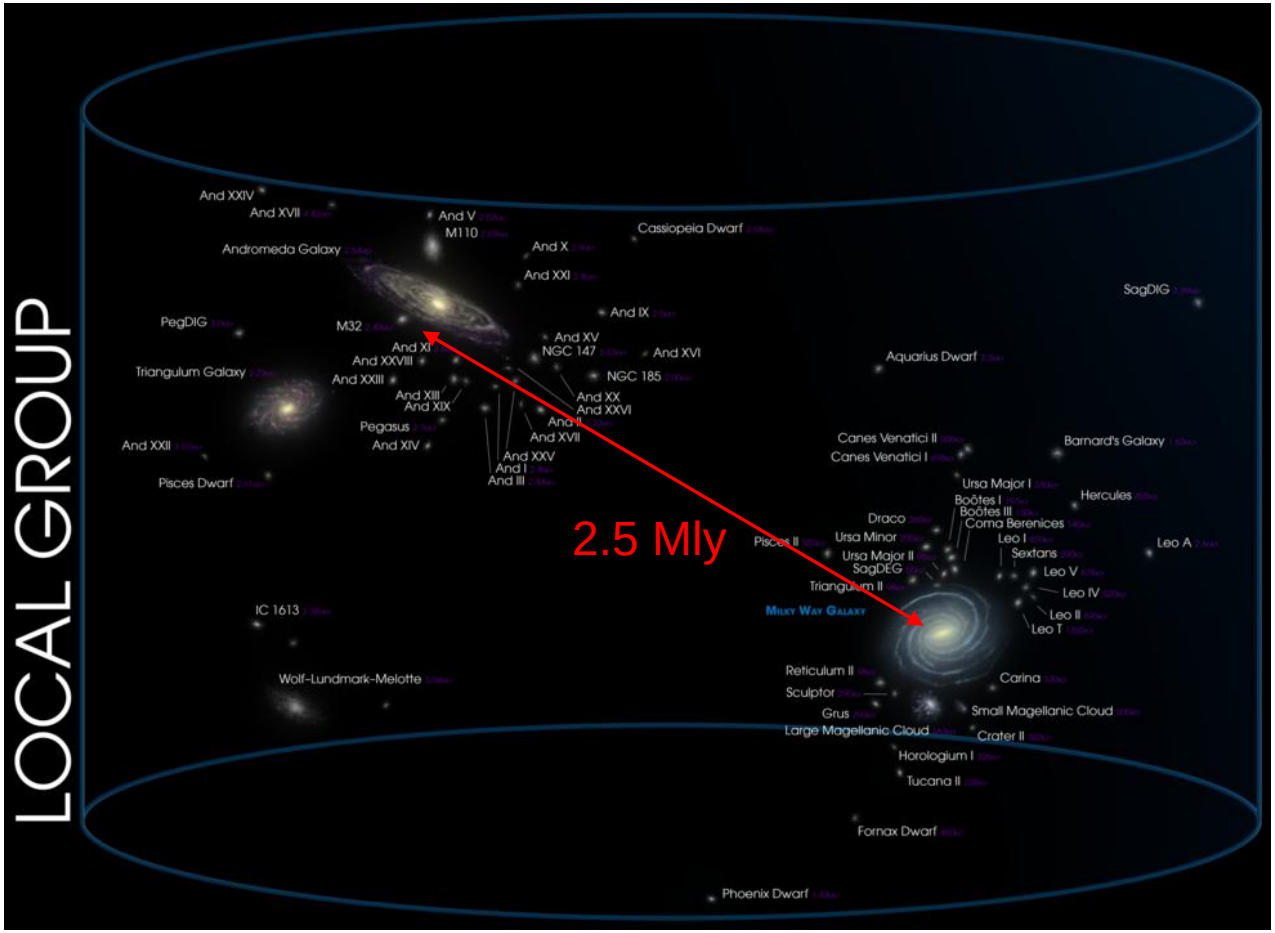
Diameter of our Galaxy = 150-200 $\times$ 10^3 ly

100-400 billion stars

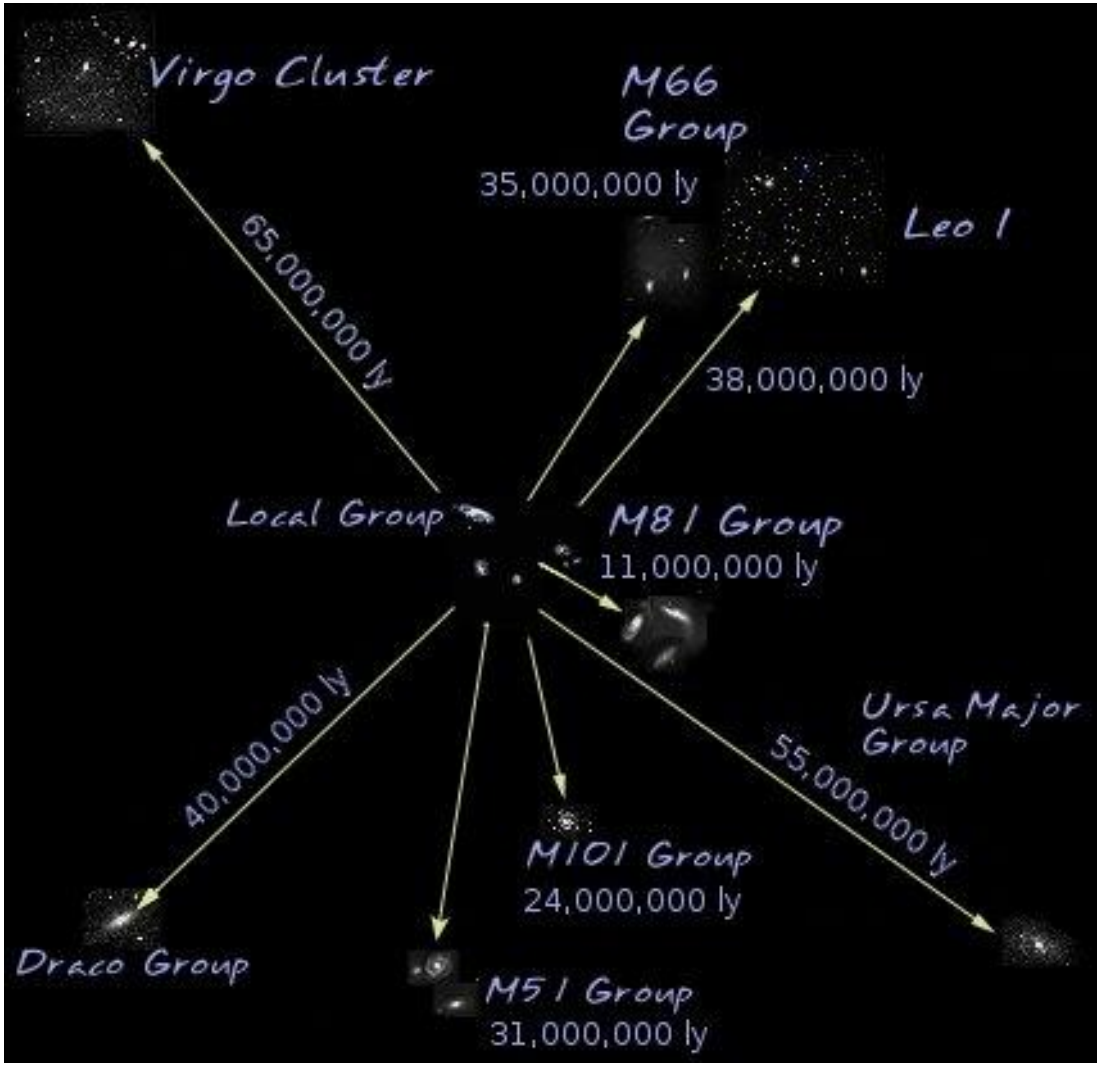


“Local Group” Scale

“Local Group” = cluster of ~ 50 nearby galaxies



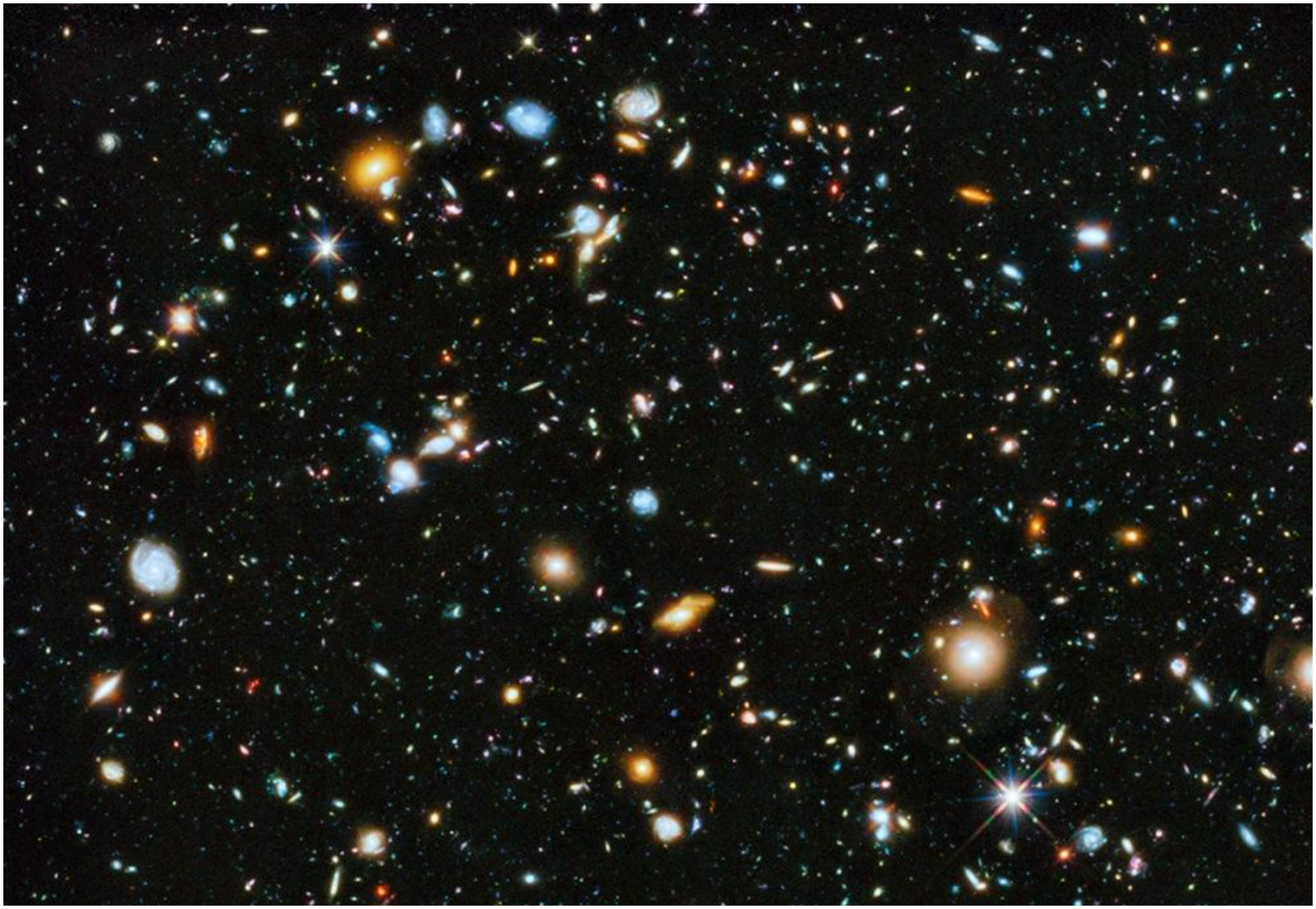
Local/Virgo Supercluster Scale



[Wikipedia; NASA]

Galaxies Everywhere

Point Hubble Space Telescope at “blank” part of the sky



[Hubble Deep Field 2014; NASA, ESA, H.Teplitz and M.Rafelski (IPAC/Caltech), A. Koekemoer (STScI), R. Windhorst(ASU), Z. Levay (STScI)]

Universe Scale
~ 93 billion ly

Number of galaxies in Universe ~ billions to trillions

… maybe more

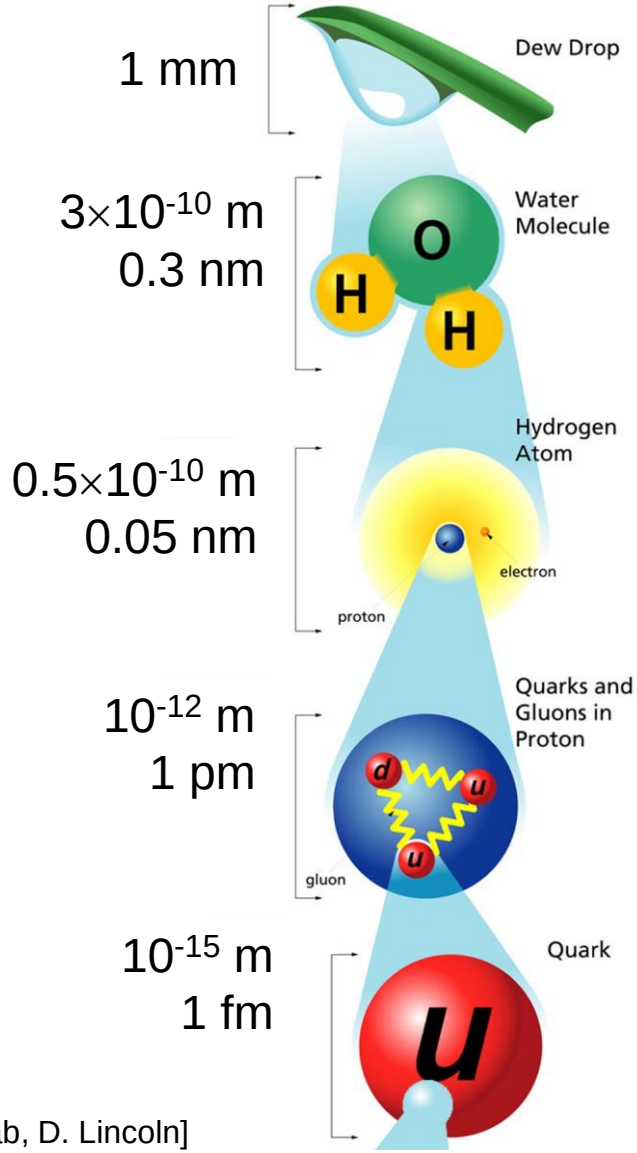
“Space is big. You just won't believe how vastly, hugely, mind-bogglingly big it is.”

- The Hitchhiker's Guide to the Galaxy

PollEv.com/sethaubin

Very Small Length Scales

"There's plenty of room at the bottom."
- Richard Feynman



[Figure adapted from FermiLab, D. Lincoln]

Powers of 10 videos

Original “Powers 10” video from 1977:

https://www.youtube.com/watch?v=0fKBhvDjuy0

(goes very big and very small)

New version of “Powers of 10” video (BBC, 2022):

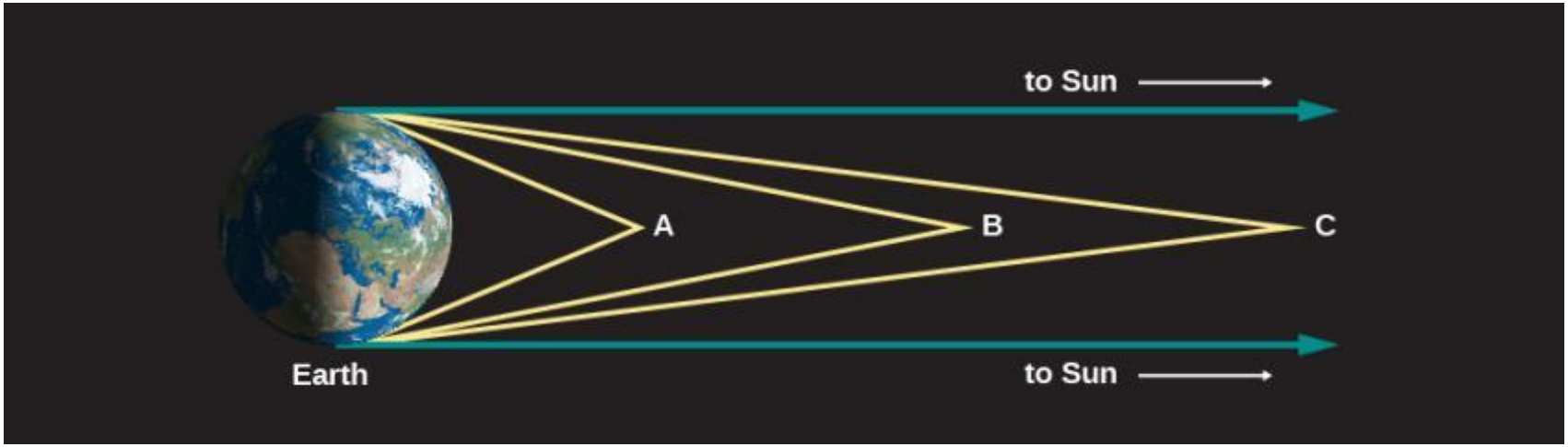
https://aeon.co/videos/revisiting-powers-of-ten-what-weve-learned-about-the-universe-since-1977

Trigonometry

Review

Ancient Greek Physics
Determining the Radius of the Earth

Parallel light rays from the sun



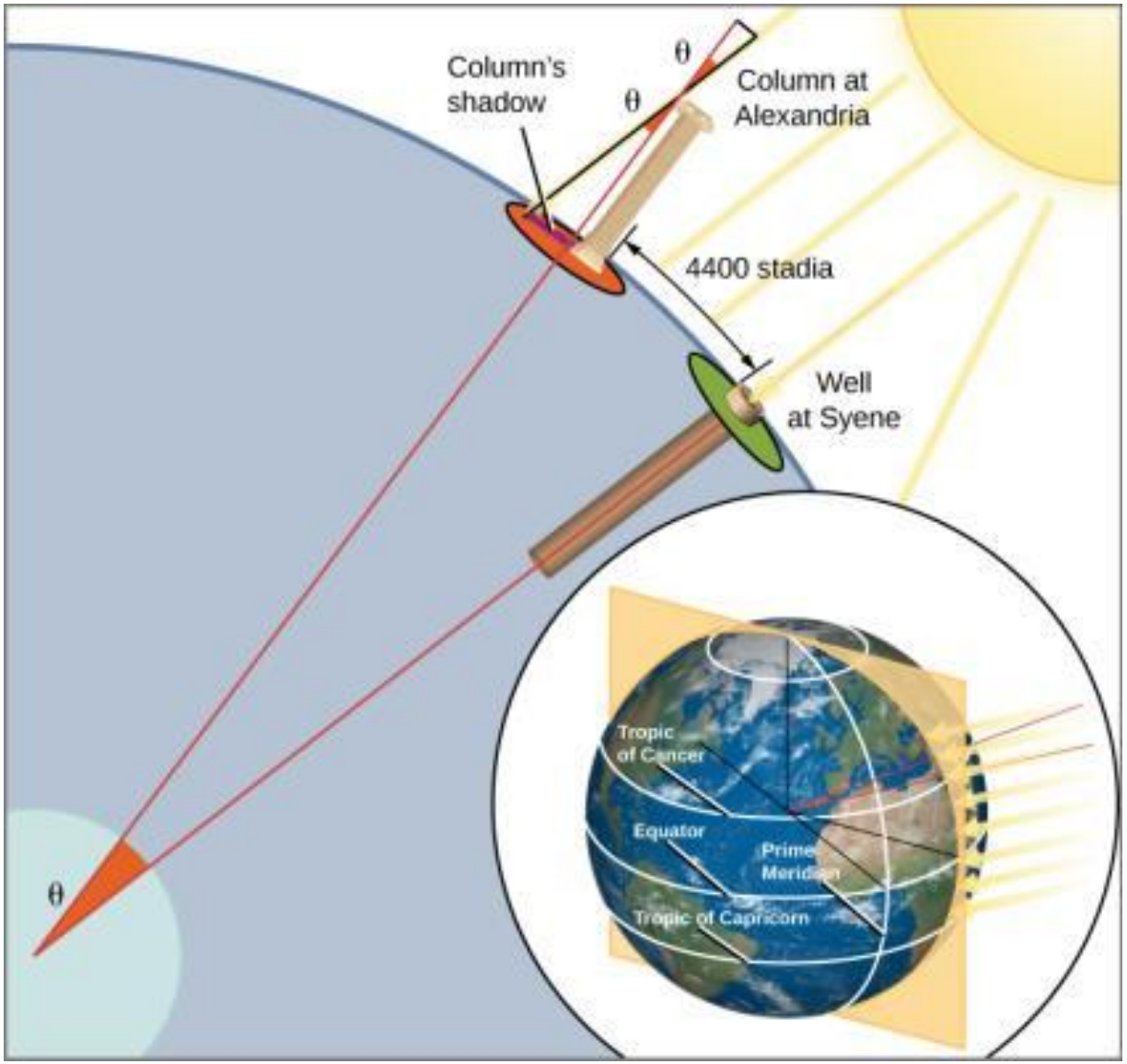
[OpenStax: Astronomy]

Light Rays from Space. The more distant an object, the more nearly **parallel** the rays of light coming from it are.

→ Light rays from Sun are quite parallel.

→ Light rays from stars are very parallel.

How Eratosthenes Measured the Size of Earth



Eratosthenes (276-194 BC) observed that:

1. A Sun's ray at **Syene** comes straight down whereas a ray at **Alexandria** makes an **angle of 7° with the vertical.**

[OpenStax; NOAA Ocean Service Education]

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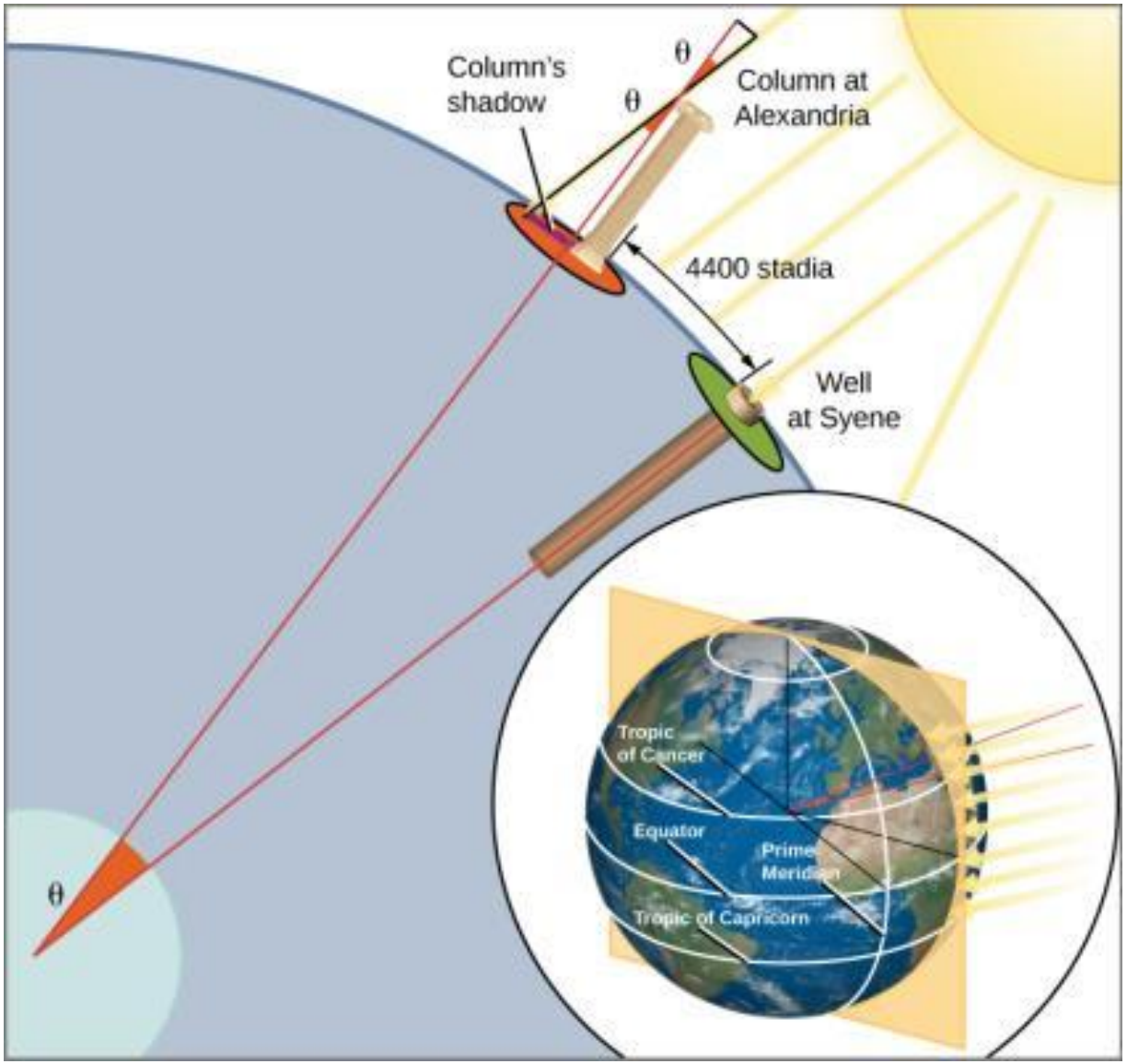

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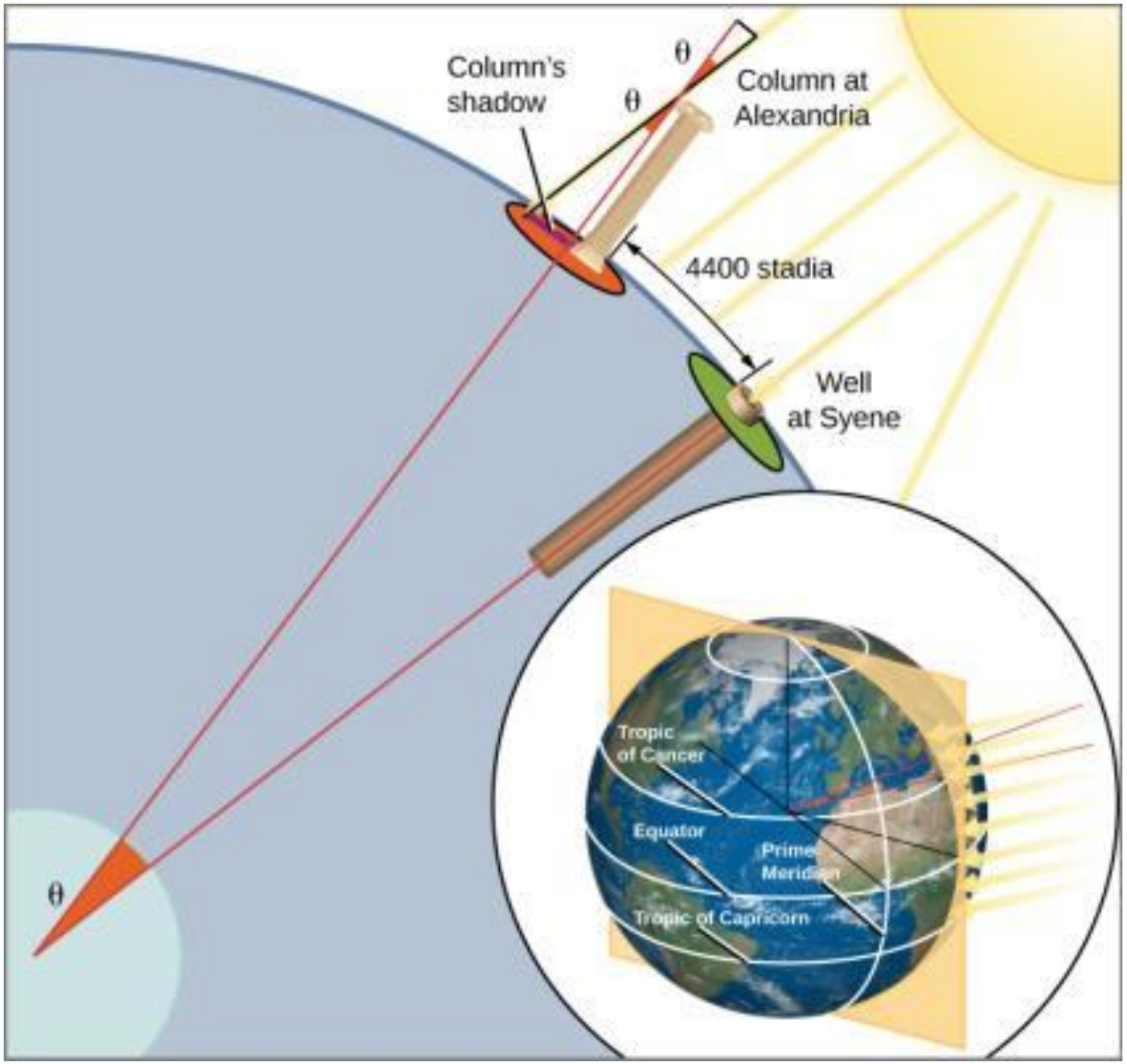

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3. The distance between the two cities, i.e. 5000 stadia, must be **1/50 the circumference** of Earth.

[OpenStax; NOAA Ocean Service Education]

How Eratosthenes Measured the Size of Earth

Circumference of Earth = 50×5000 stadia

= 250,000 stadia *(1 stadia ~ 180 m)*

$\approx$ 45,000 km

Actual circumference of Earth = 40,000 km

How Eratosthenes Measured the Size of Earth

Circumference of Earth = 50×5000 stadia

= 250,000 stadia *(1 stadia ~ 180 m)*

$\approx$ 45,000 km

→ Radius =$45{,}000/2\pi \approx 7{,}200$ km

Actual circumference of Earth = 40,000 km

→ Radius =$40{,}000/2\pi \approx 6{,}400$ km