

Ancient Greek Astronomy: The Distance to the Moon and the Sun

Denis Erkal



Astronomy Today

- Huge Ground-Based Telescopes



Very Large Telescope (VLT)

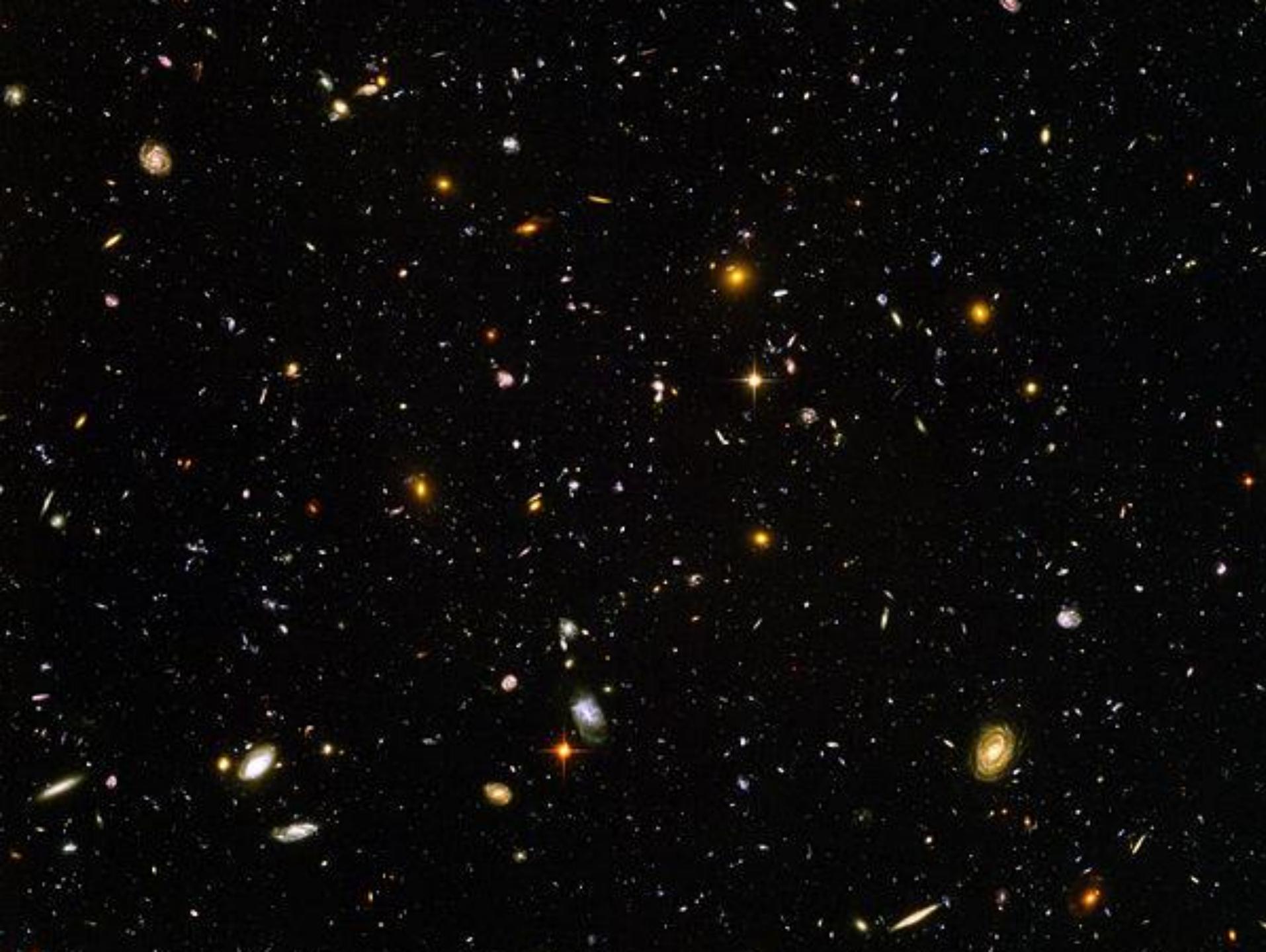


Astronomy Today

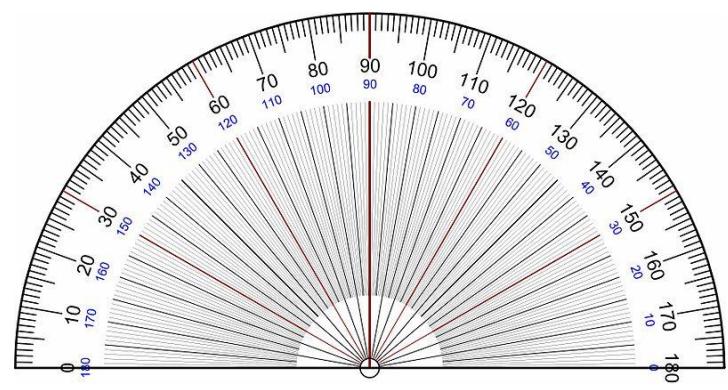
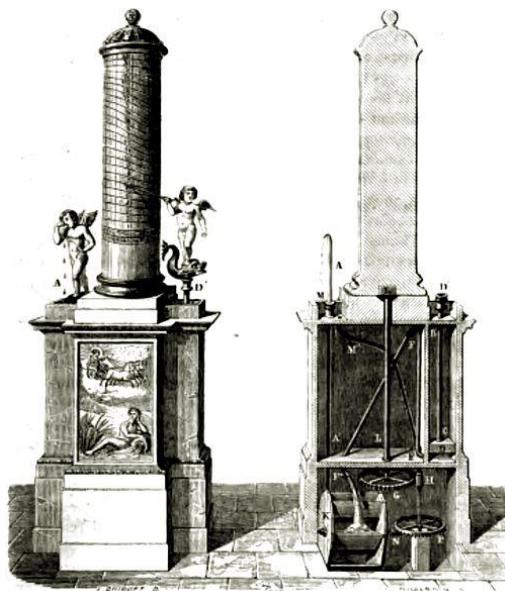
- Telescopes in Space



Hubble Space Telescope



Astronomy 2500 Years Ago

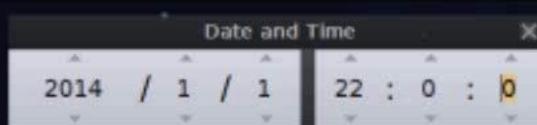










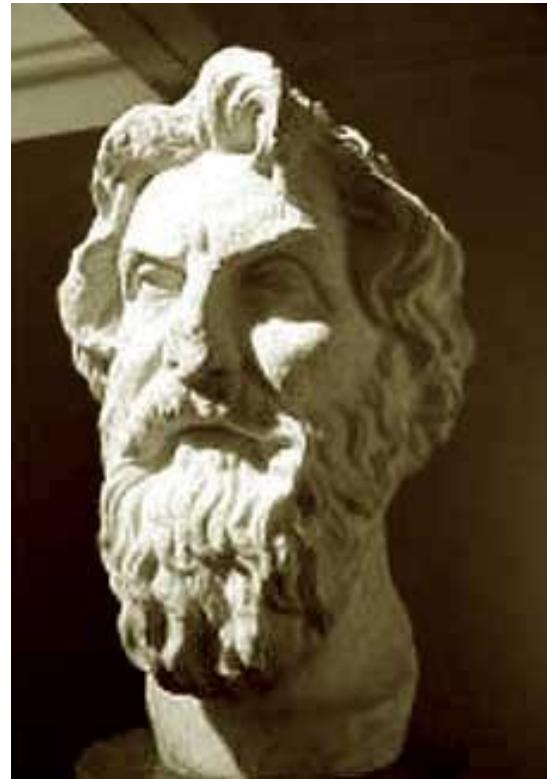


Progression of Ideas

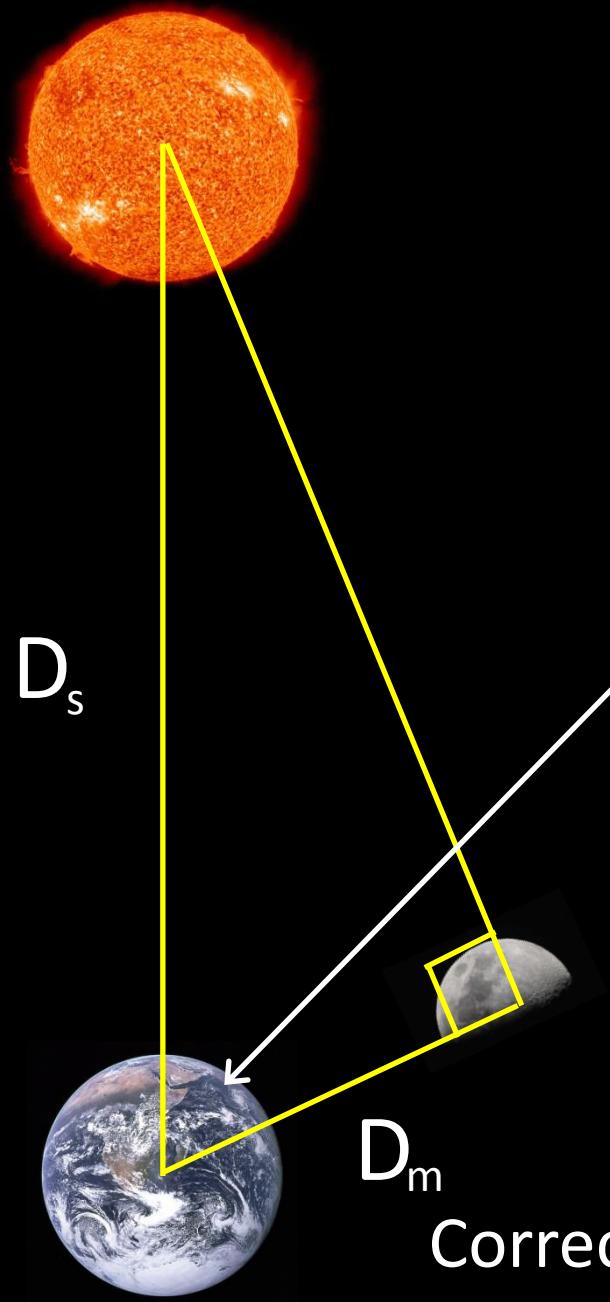
- 550 BC – First mention of eclipse (**Thales**)
- 530 BC – Planets mentioned (**Anaximenes**)
- 510 BC – East to west motion of stars
(**Pythagoras**)
- 450 BC – Moon reflects light from sun, first correct explanation of eclipse (**Anaxagoras**)
- 400 BC – Circular orbits for planets around Earth (**Pythagoreans**)

Aristarchus of Samos

310 BC – 230 BC



“On the Size and Distances of the Sun and Moon”



$$1/\cos(87^\circ) = 19.1$$

$$D_s = 19.1 D_m$$

Correct Value: $D_s = 389 D_m$

πρὸς τῷ Ε, τὸ ἄρα ἀπὸ τῆς ΖΕ πρὸς τὸ ΗΕ
ώς δὲ τὸ ἀπὸ ΖΒ πρὸς τὸ ἀπὸ ΒΕ, οὗτος ἐστὶ τὸ ἀπὸ ΖΗ πρὸς τὸ
5 ἀπὸ ΗΕ· τὸ ἄρα ἀπὸ ΖΗ τοῦ ἀπὸ ΗΕ διπλάσιόν ἐστι. τὰ δὲ μθ
τῶν κε ἐλάσσονά ἐστιν ἢ διπλάσια, ὥστε τὸ ἀπὸ ΖΗ πρὸς τὸ ἀπὸ

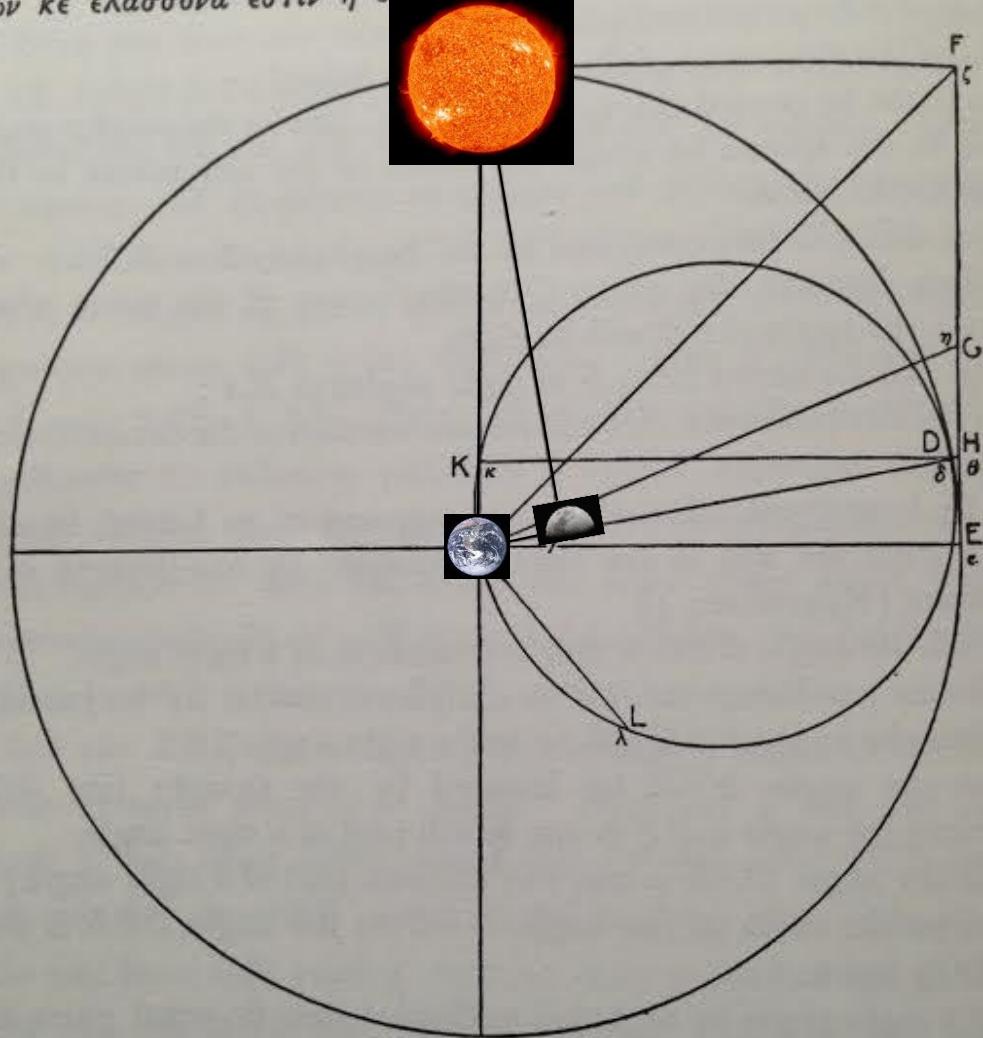
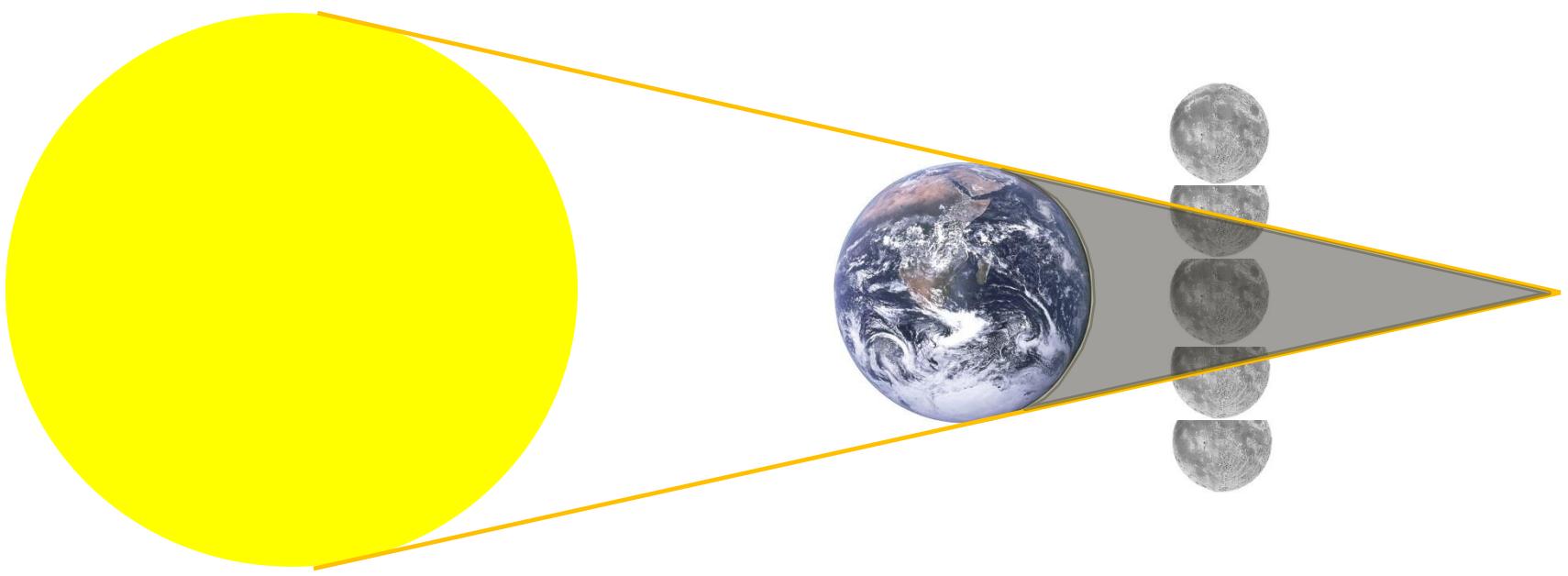


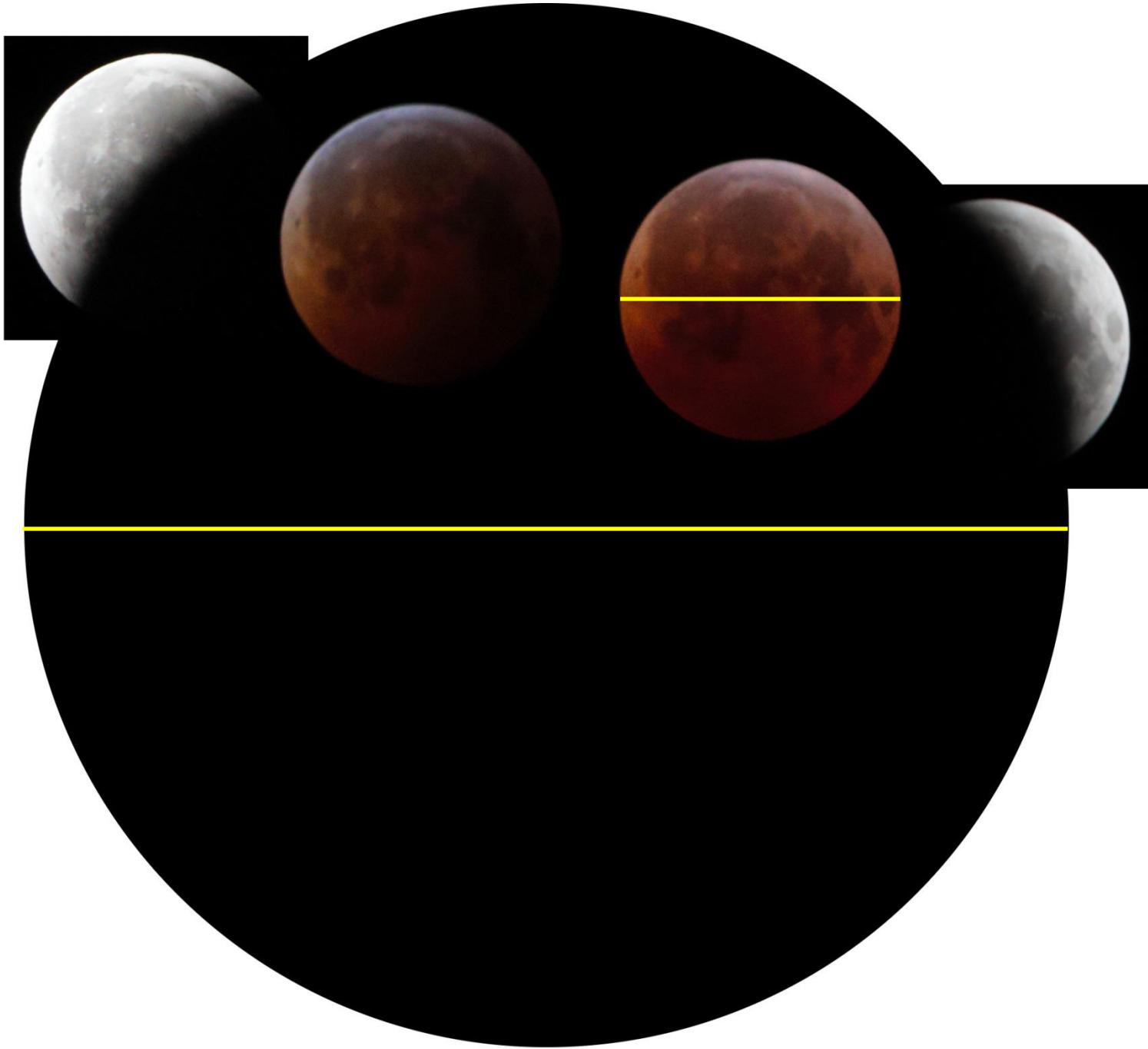
Fig. 25.

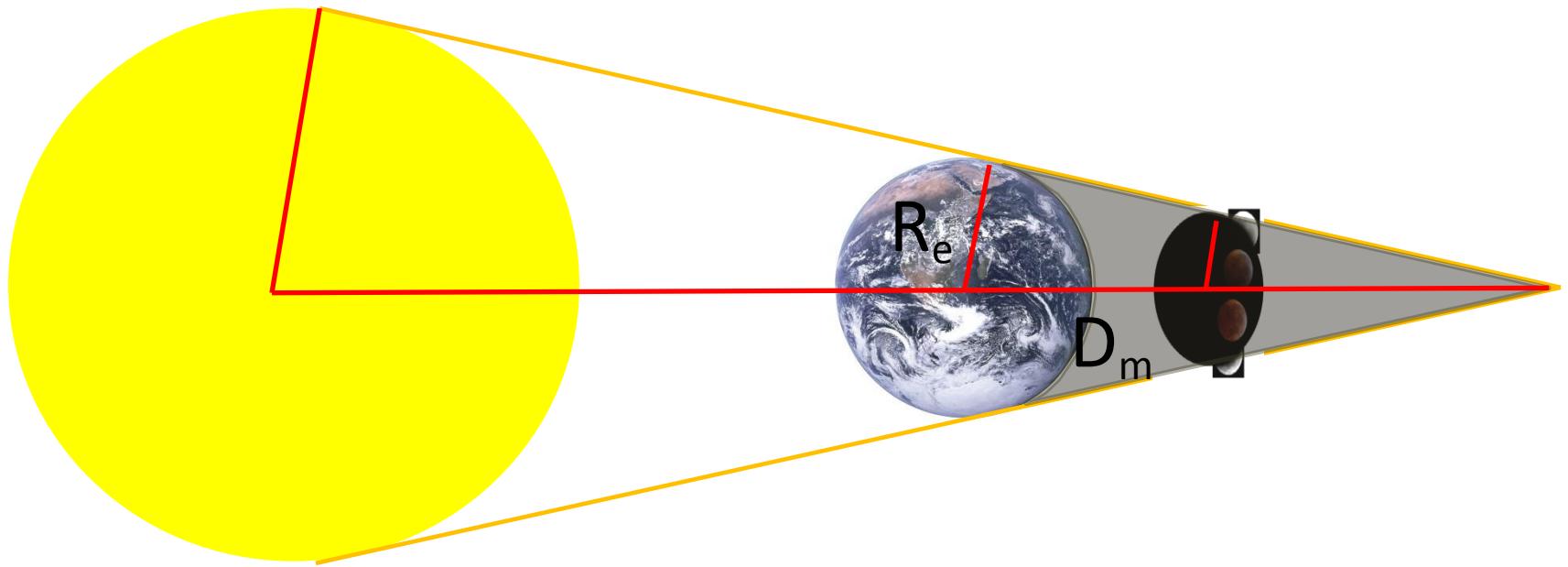
ΗΕ μείζονα λόγον ἔχει ἢ (δν τὰ) μθ πρὸς κε· καὶ ἡ ΖΙ
ἄρα πρὸς τὴν ΗΕ μείζονα λόγον ἔχει ἢ (δν) τὰ ζ πρὸς τὰ ε· καὶ
συνθέντι ἡ ΖΕ ἄρα πρὸς τὴν ΕΗ μείζονα λόγον ἔχει ἢ δν τὰ ε·
10 πρὸς τὰ ε· τουτέστιν. ἢ δν (τὰ) λε πρὸς τὰ ε· δεῖθενθη δὲ καὶ

After several pages of
geometry...

$$18D_m < D_s < 20D_m$$







$$23.82R_e > D_m > 14.25 R_e$$

$$D_m = 20.72 R_e$$

Correct Value: $D_m = 60.3 R_e$

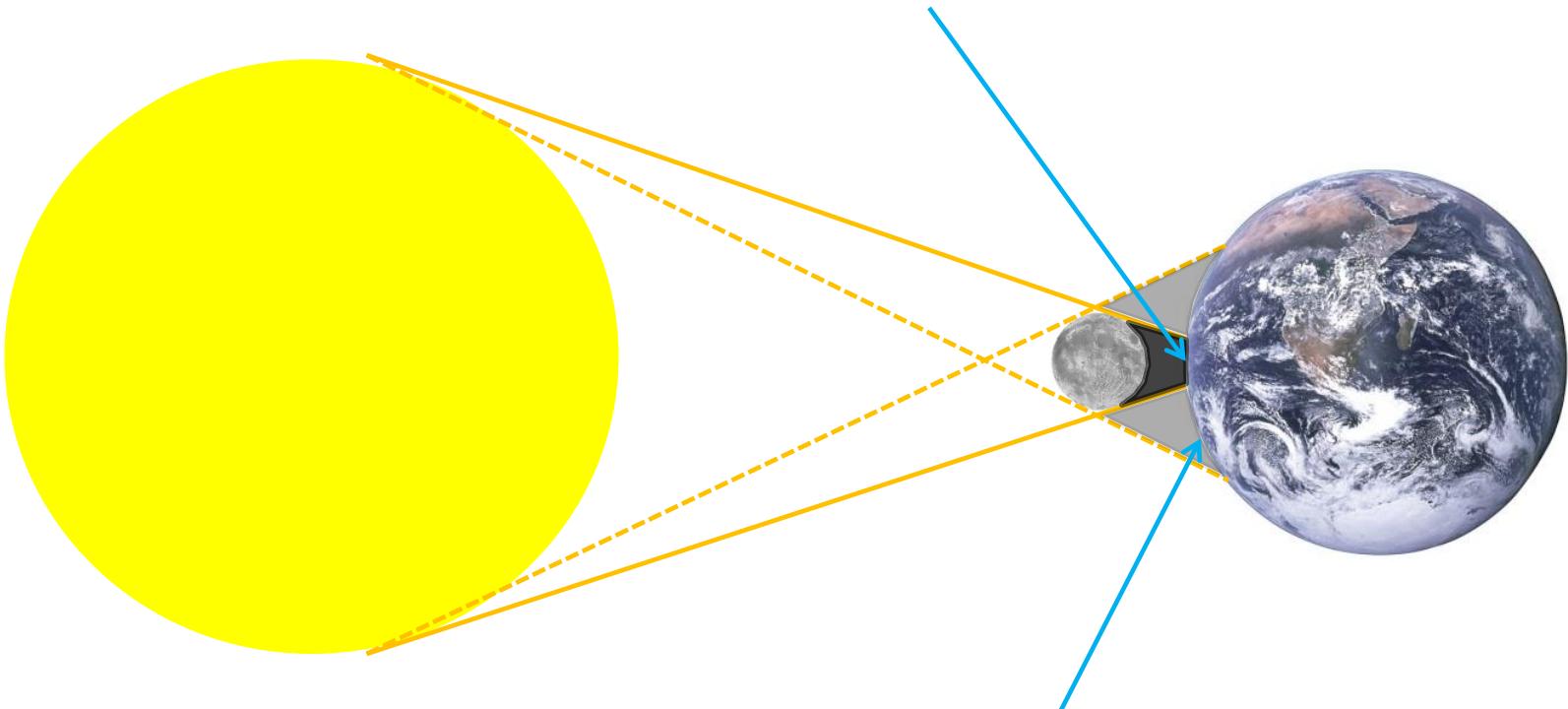
	Year	Distance to Moon	Distance to Sun
	Today	$60.3 R_e$	$389 D_m$
Aristarchus	$\sim 250 \text{ BC}$	$19 R_e$	$20 D_m$

Hipparchus of Nicaea

190 BC – 120 BC



“On Sizes and Distances”



A diagram illustrating a solar eclipse. On the left, a large yellow circle represents the Sun. In the center, a smaller grey circle represents the Moon. To the right, a blue-grey sphere represents Earth. Dashed lines connect the Sun and Moon to the Earth. A thick black band on the Earth's surface indicates the path of totality, where a total eclipse occurs. Two blue arrows point from the text labels to this band: one arrow points from the top text 'Total Eclipse' to the upper part of the band, and another arrow points from the bottom text 'Partial Eclipse' to the lower part of the band.

Total Eclipse

Partial Eclipse

	Year	Distance to Moon	Distance to Sun
	Today	60.3 R_e	389 D_m
Aristarchus	~250 BC	19 R_e	20 D_m
Hipparchus	~140 BC	68 R_e	37 D_m

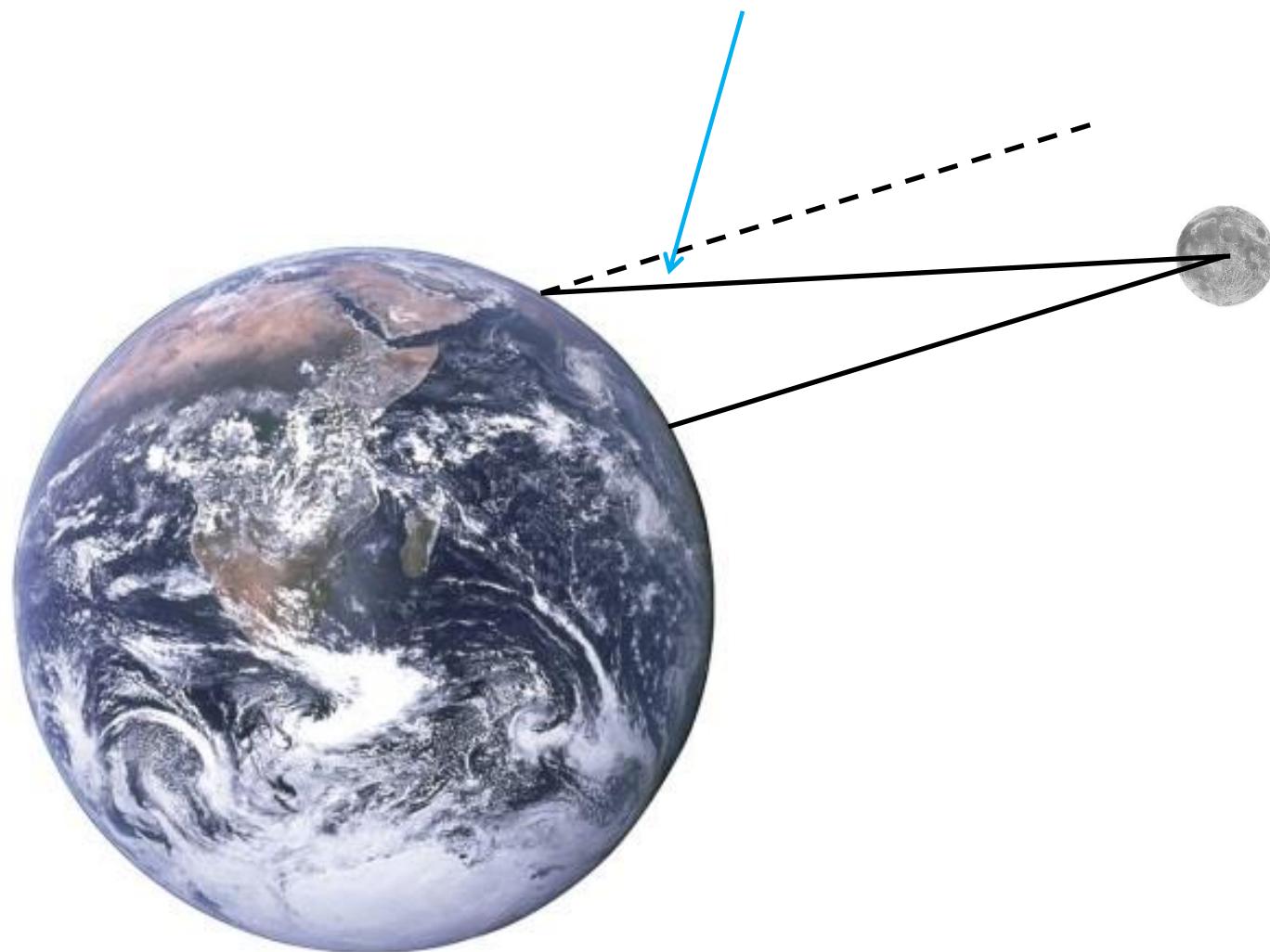
Claudius Ptolemy

90 AD – 168 AD



“Almagest”

Parallax



	Year	Distance to Moon	Distance to Sun
	Today	60.3 R_e	389 D_m
Aristarchus	~250 BC	19 R_e	20 D_m
Hipparchus	~140 BC	68 R_e	37 D_m
Ptolemy	150 AD	59 R_e	21 D_m

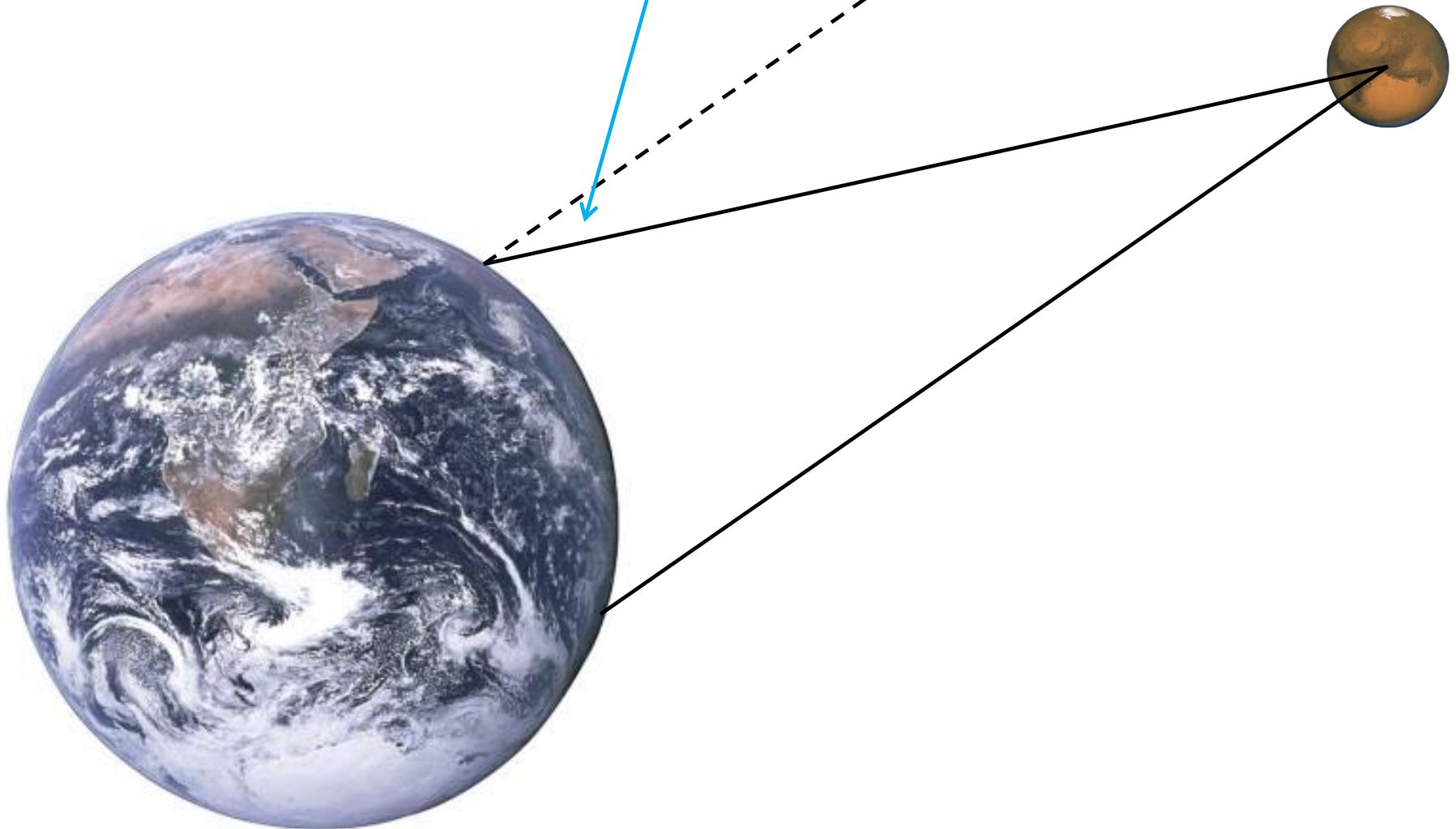
Giovanni Domenico Cassini
1625-1712 AD



Jean Richer
1630-1696 AD



Parallax



	Year	Distance to Moon	Distance to Sun
	Today	60.3 R_e	389 D_m
Aristarchus	~250 BC	19 R_e	20 D_m
Hipparchus	~140 BC	68 R_e	37 D_m
Ptolemy	150 AD	59 R_e	21 D_m
Cassini and Richer	1670 AD		364 D_m

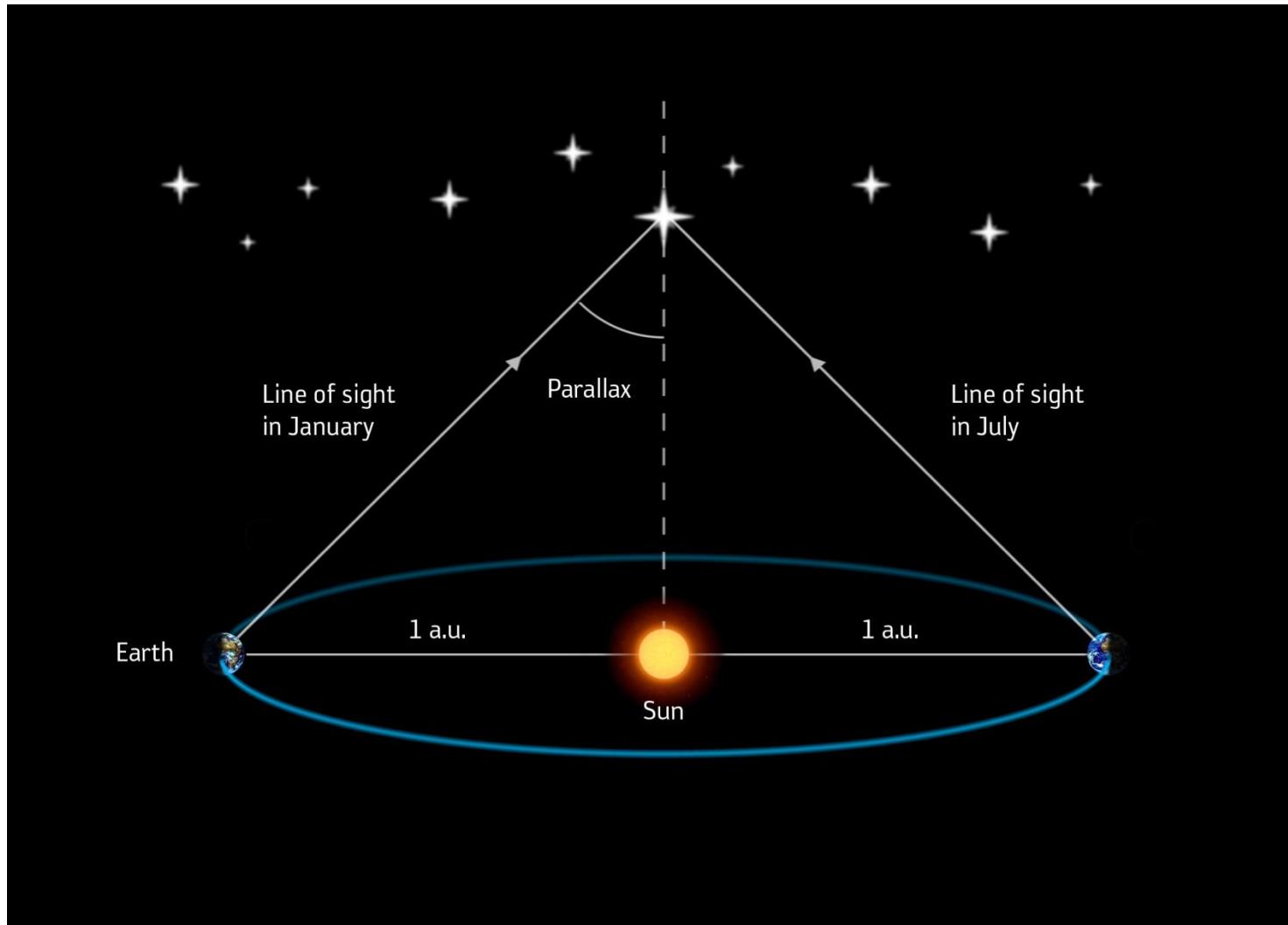
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Ptolemy	150 AD	59 R_e	21 D_m
Cassini and Richer	1670 AD		364 D_m
Me	2011 AD	62 R_e	40 D_m

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Ptolemy	150 AD	59 R_e	21 D_m
Cassini and Richer	1670 AD		364 D_m
Me	2011 AD	62 R_e	40 D_m
You	?		

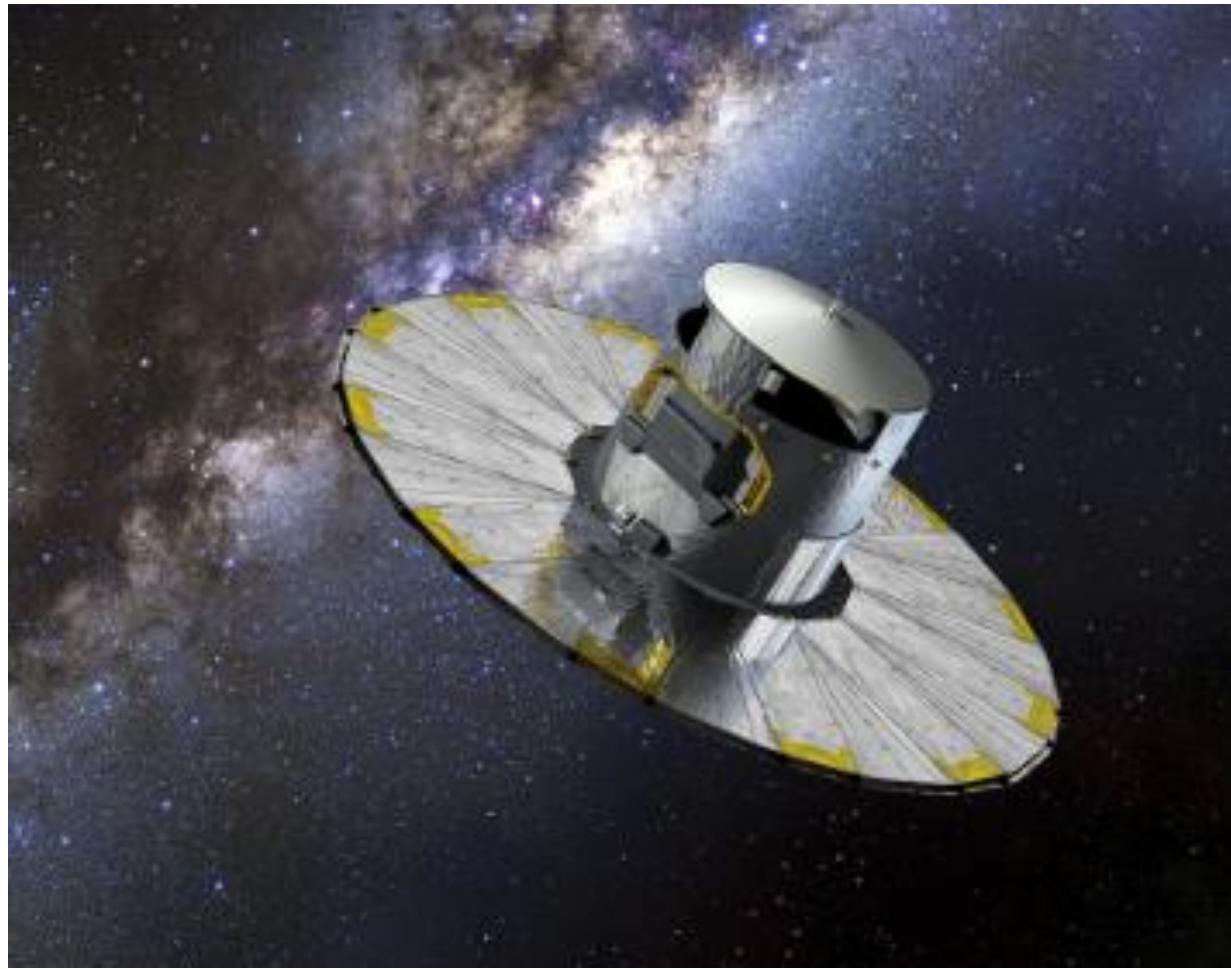
Other Ancient Discoveries

- **Earth orbits the sun:** Aristarchus ~250 BC
- **Size of the earth:** Eratosthenes ~200 BC
- **Precession of earth's axis:** Hipparchus ~130 BC
- **Moon distance variation:** Ptolemy ~150 AD
- **Evidence for solar distance variation:** Ptolemy ~150 AD

Same techniques in use today



Gaia Satellite



Gaia will determine the position of **1 billion** stars