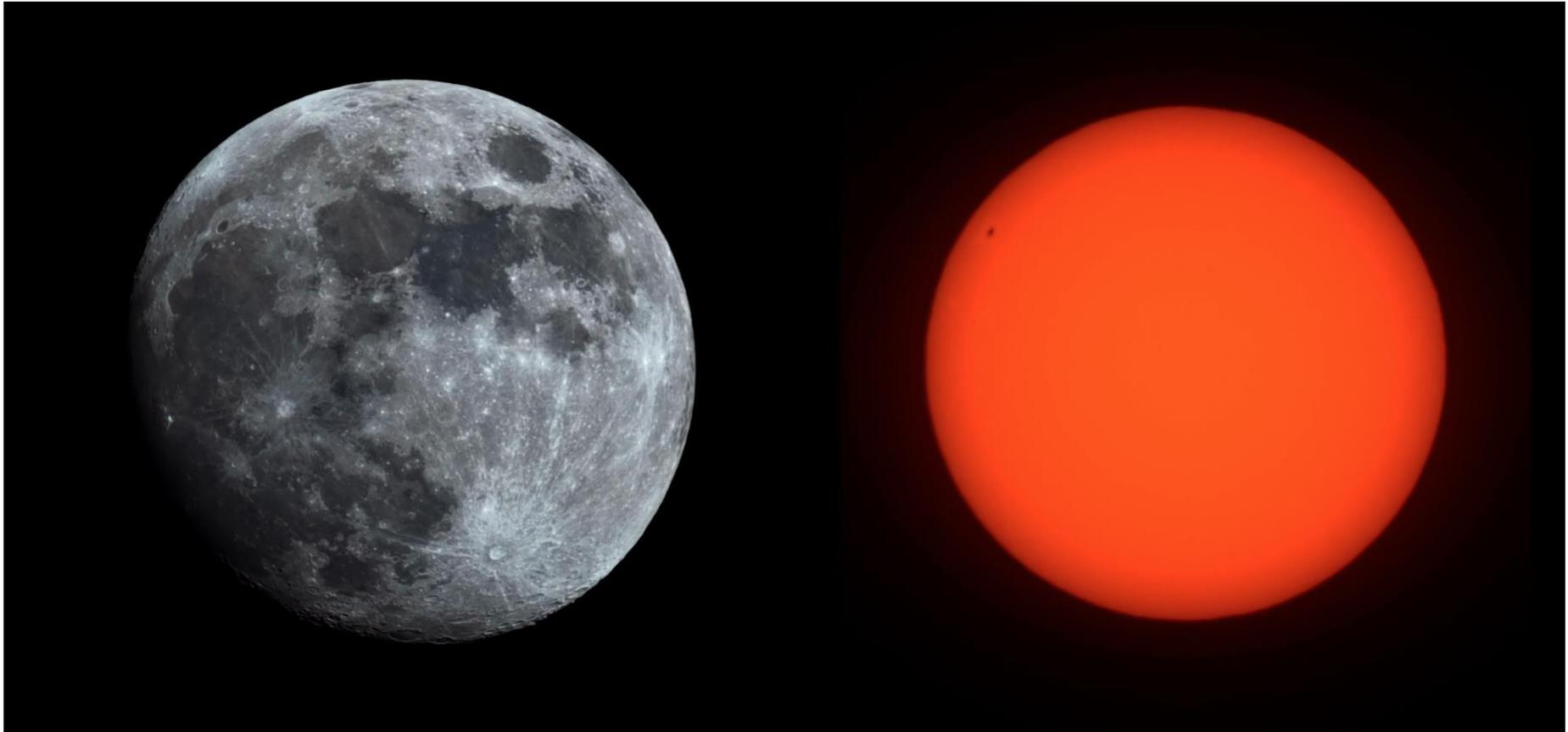


# Ancient Greek Astronomy: The Distance to the Moon and the Sun



# Astronomy Today

- Huge Ground-Based Telescopes



Very Large Telescope (VLT) – 8 meter mirror

# Astronomy Today

- Huge Ground-Based Telescopes



Vera Rubin Observatory – 8.4 meter mirror

NSF-DOE Rubin's First

**LOOK**

VERA C. RUBIN OBSERVATORY | U.S. National Science Foundation | U.S. Department of Energy | Office of Science



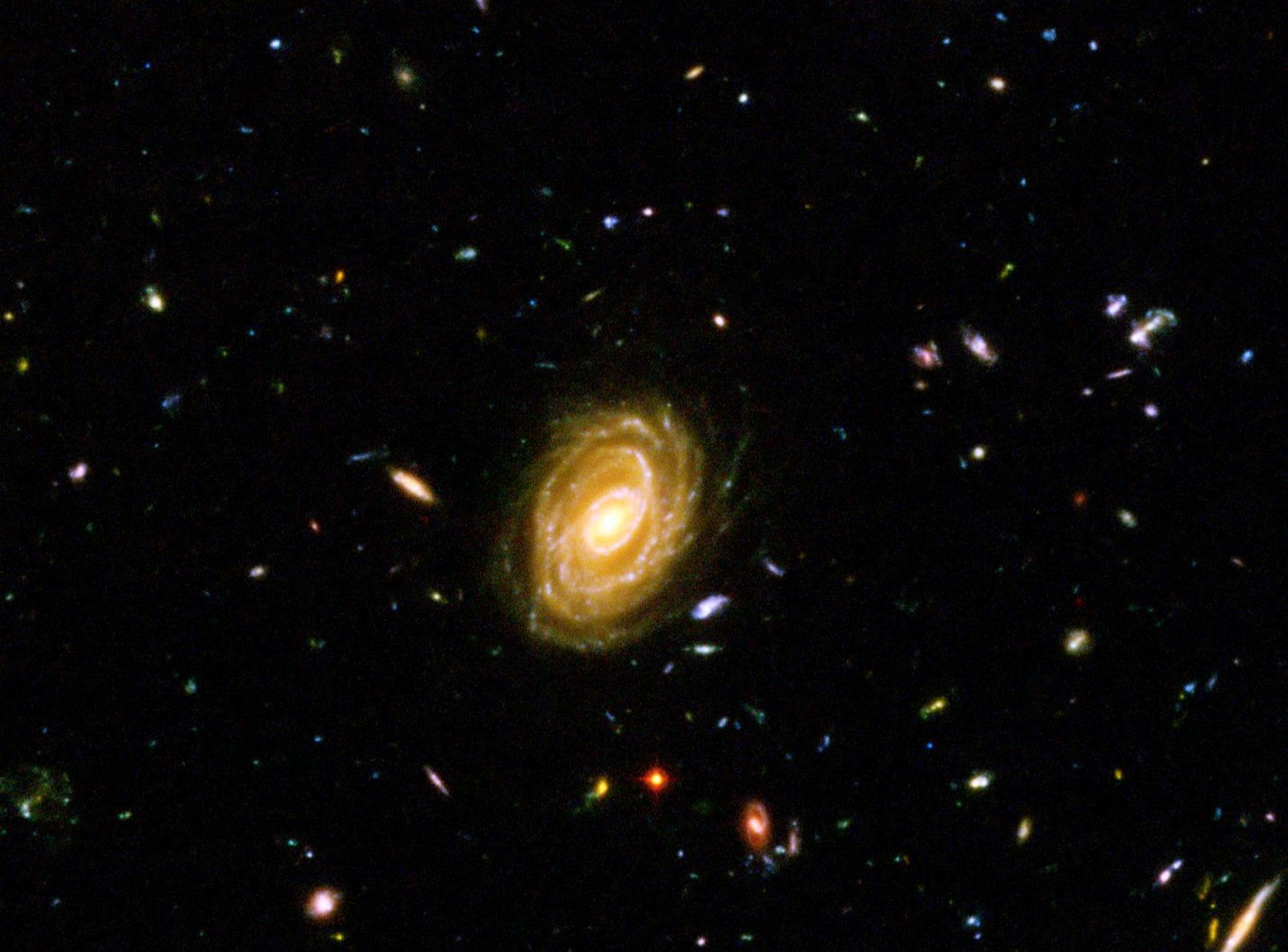
# Astronomy Today

- Telescopes in Space



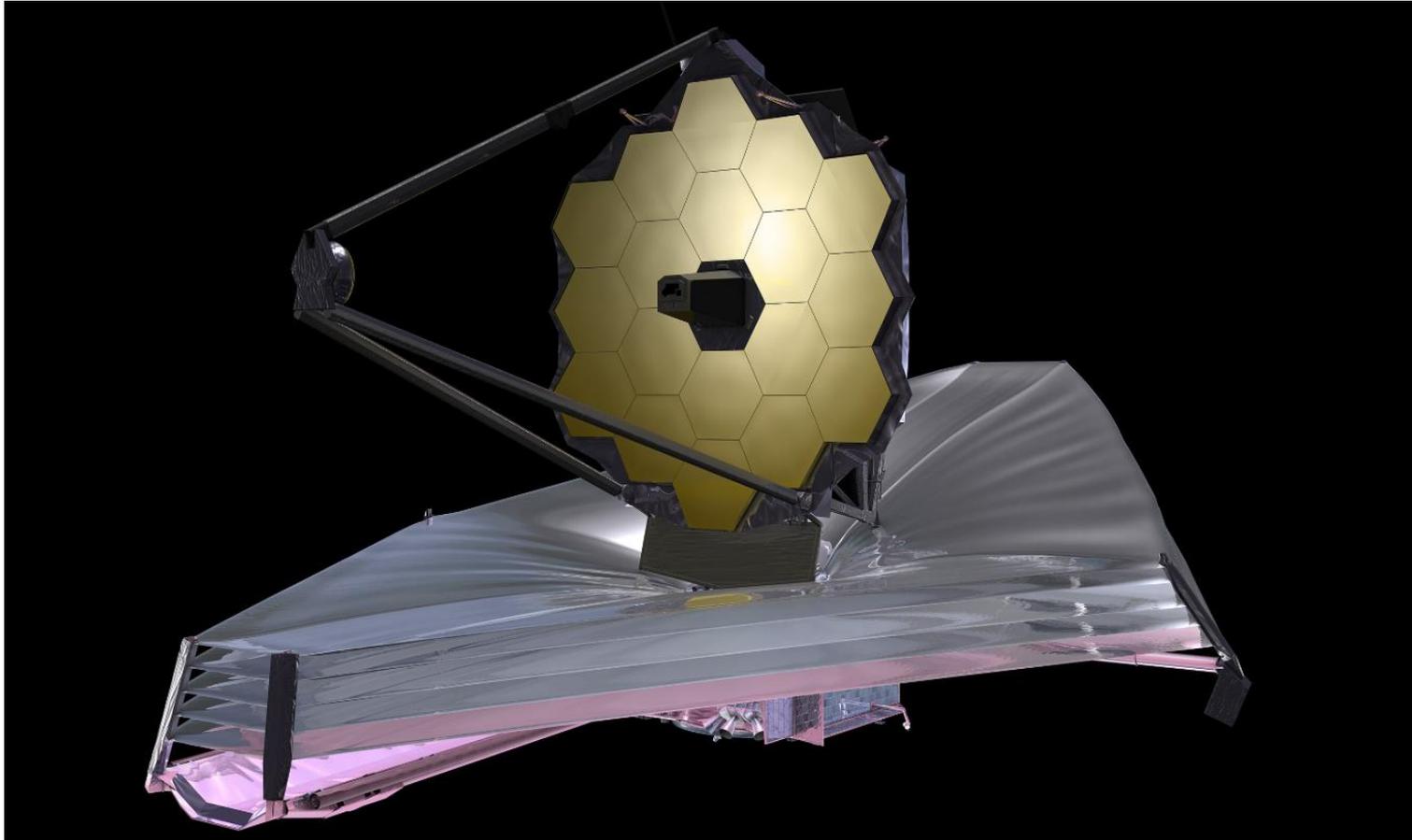
Hubble Space Telescope – 2.4 meter mirror





# Astronomy Today

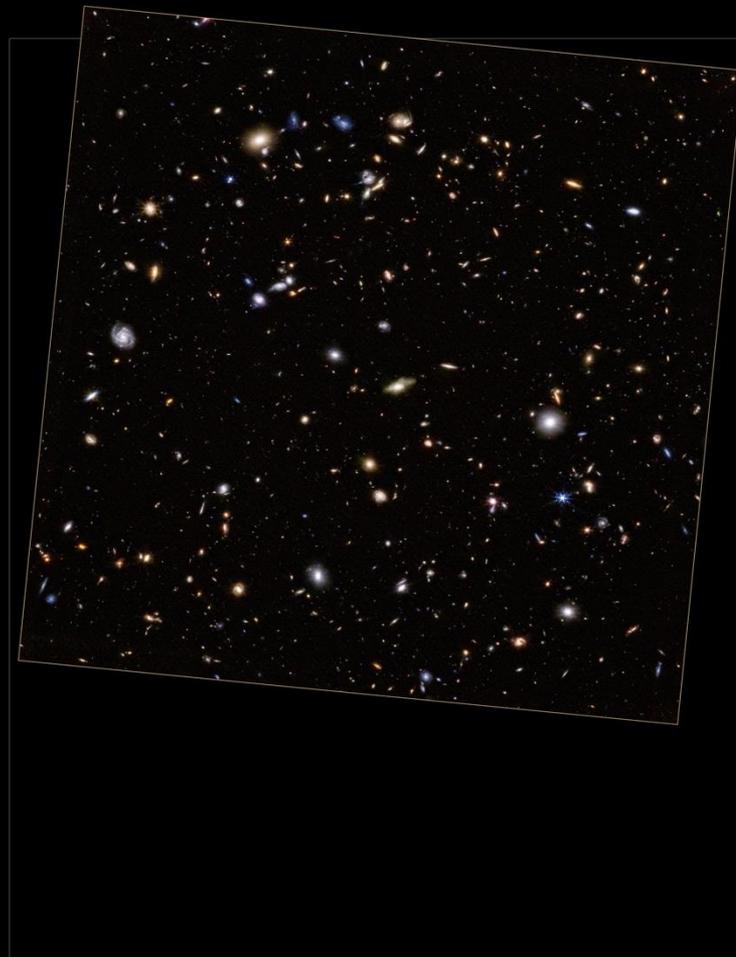
- Telescopes in Space



JWST – 6.5 meter mirror



Hubble UDF (exposure time: 11.3 days)

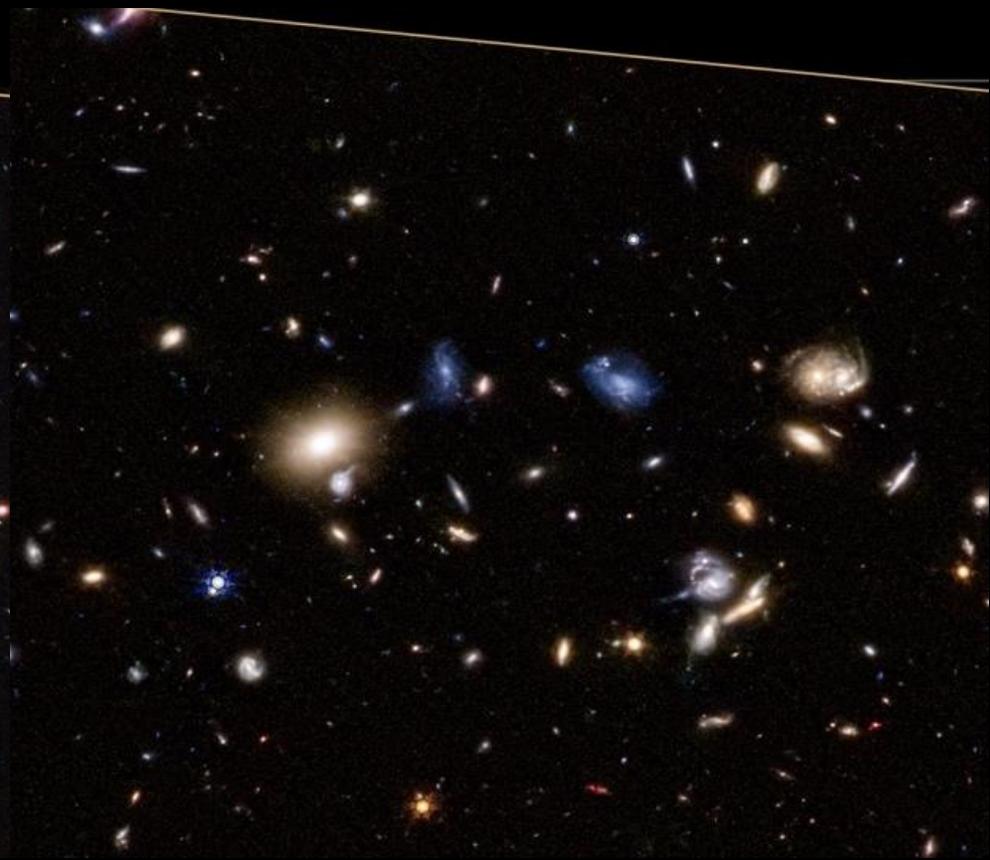


Webb (exposure time: 0.83 days)

HST

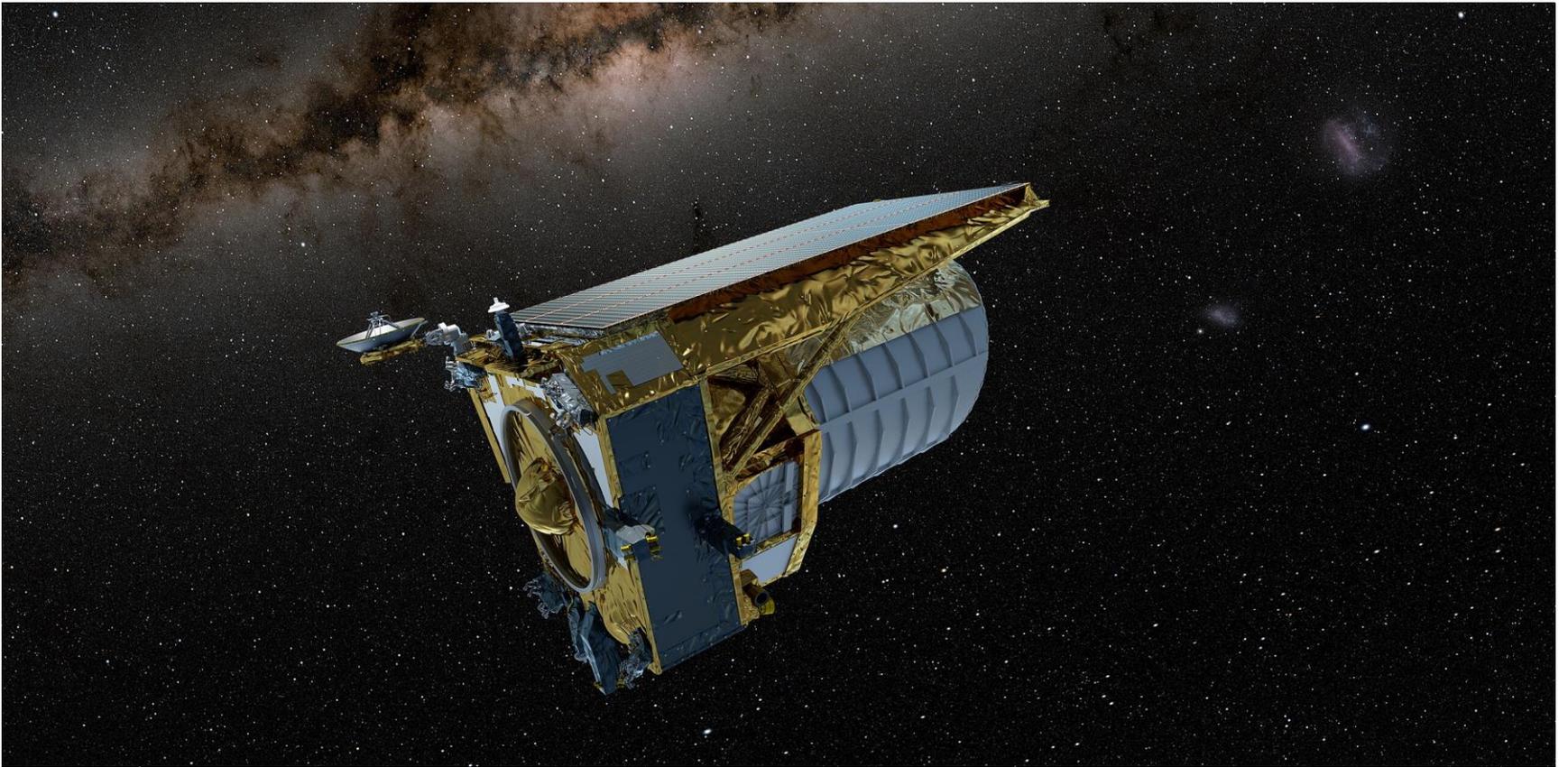


JWST



# Astronomy Today

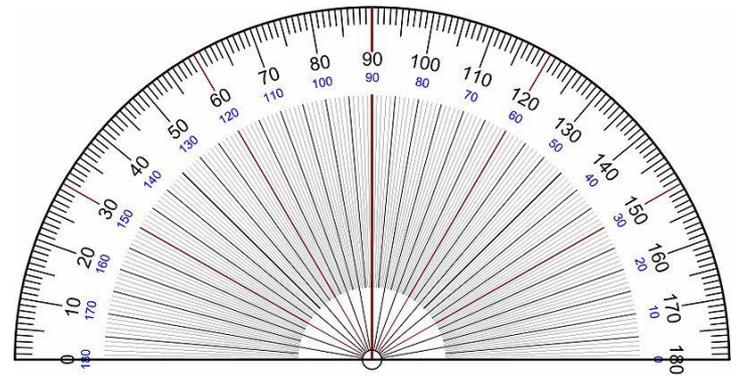
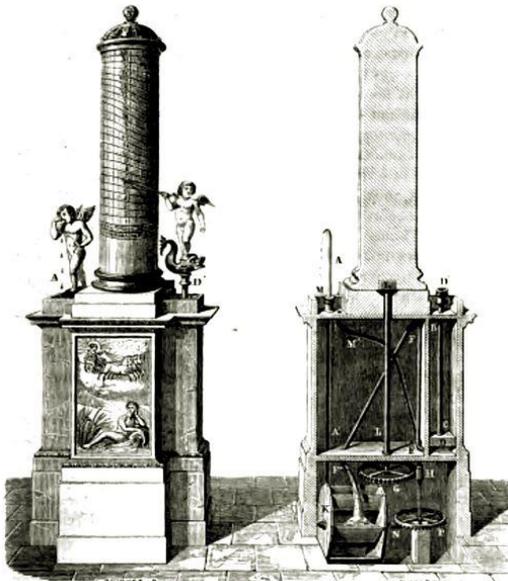
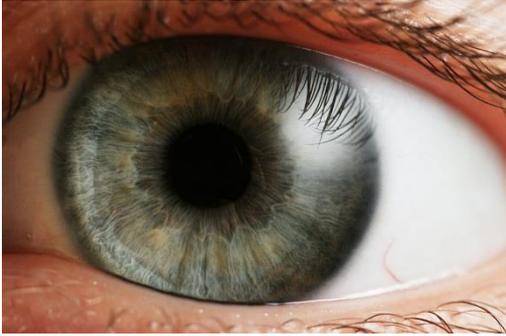
- Telescopes in Space



Euclid – 1.2 meter mirror



# Astronomy 2500 Years Ago







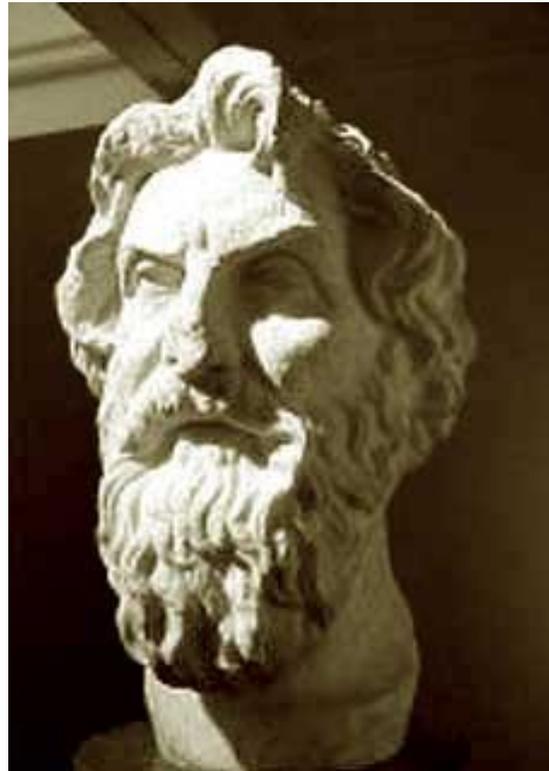


# Progression of Ideas

- 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”

# Distance to the Sun



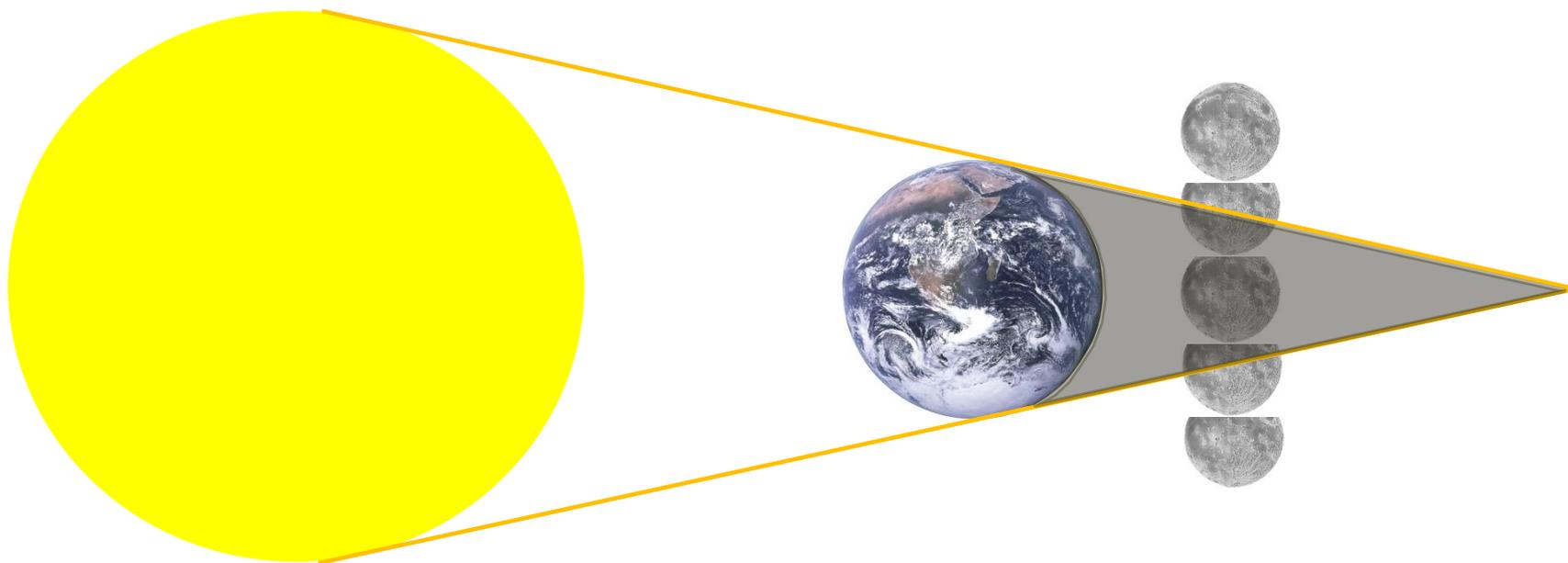
$$1/\cos(87^\circ) = 19.1$$

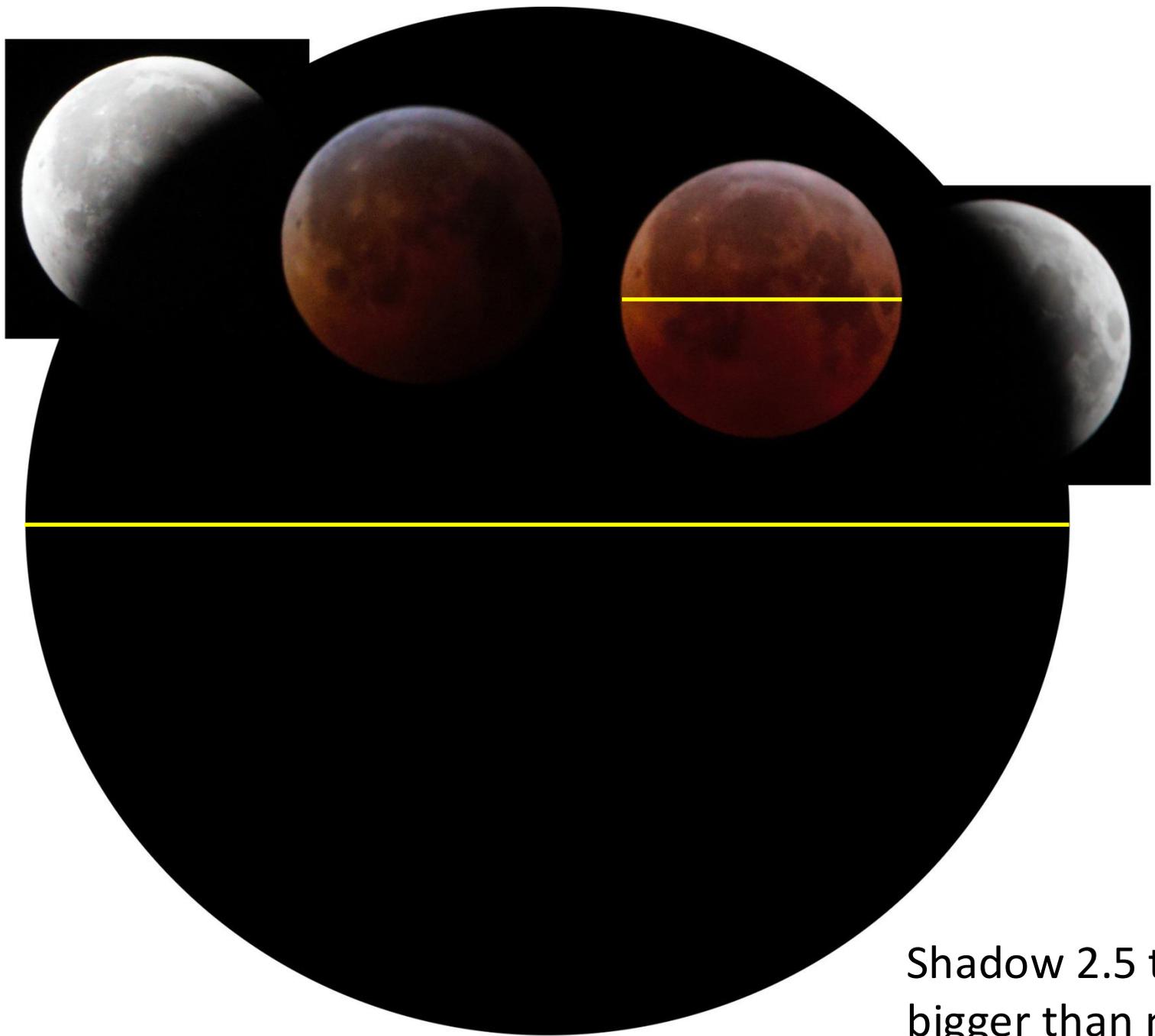
$$D_s = 19.1 D_m$$

Correct Value:  $D_s = 389 D_m$

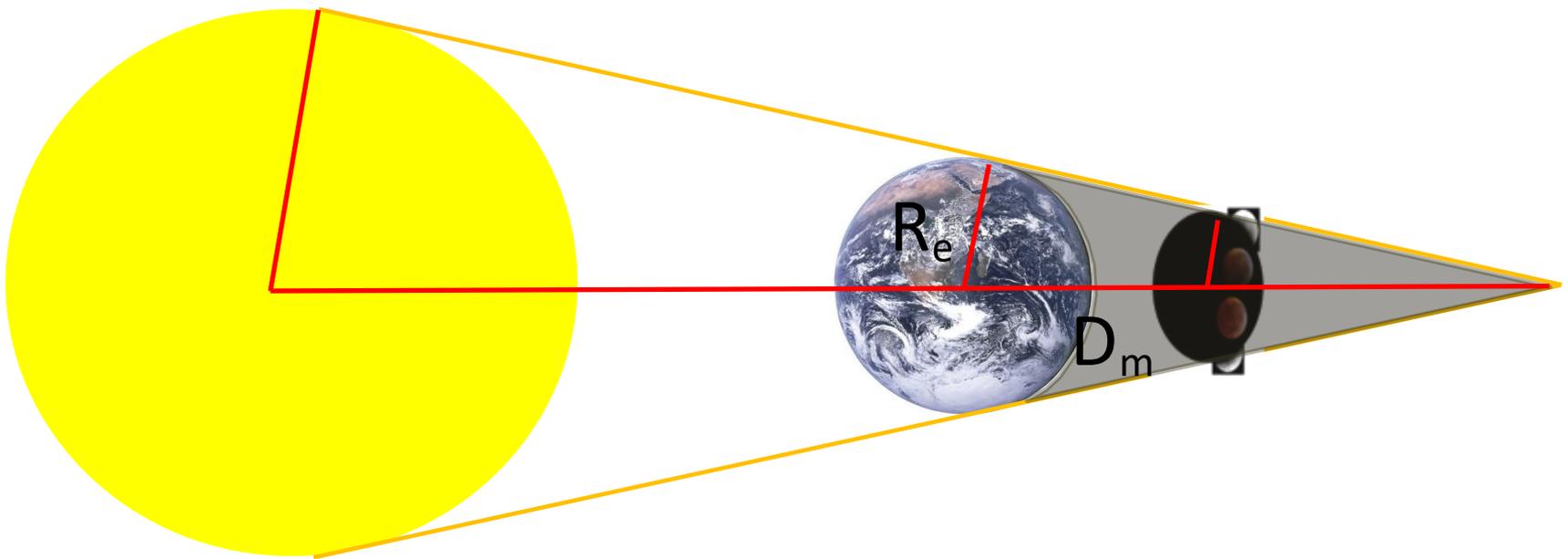


# Distance to the Moon





Shadow 2.5 times  
bigger than moon



$$23.82R_e > D_m > 14.25 R_e$$

$$D_m = 20.72 R_e$$

Correct Value:  $D_m = 60.3 R_e$

	Year	Distance to Moon	Distance to Sun
	Today	60.3 $R_e$	389 $D_m$
Aristarchus	~250 BC	19 $R_e$	20 $D_m$

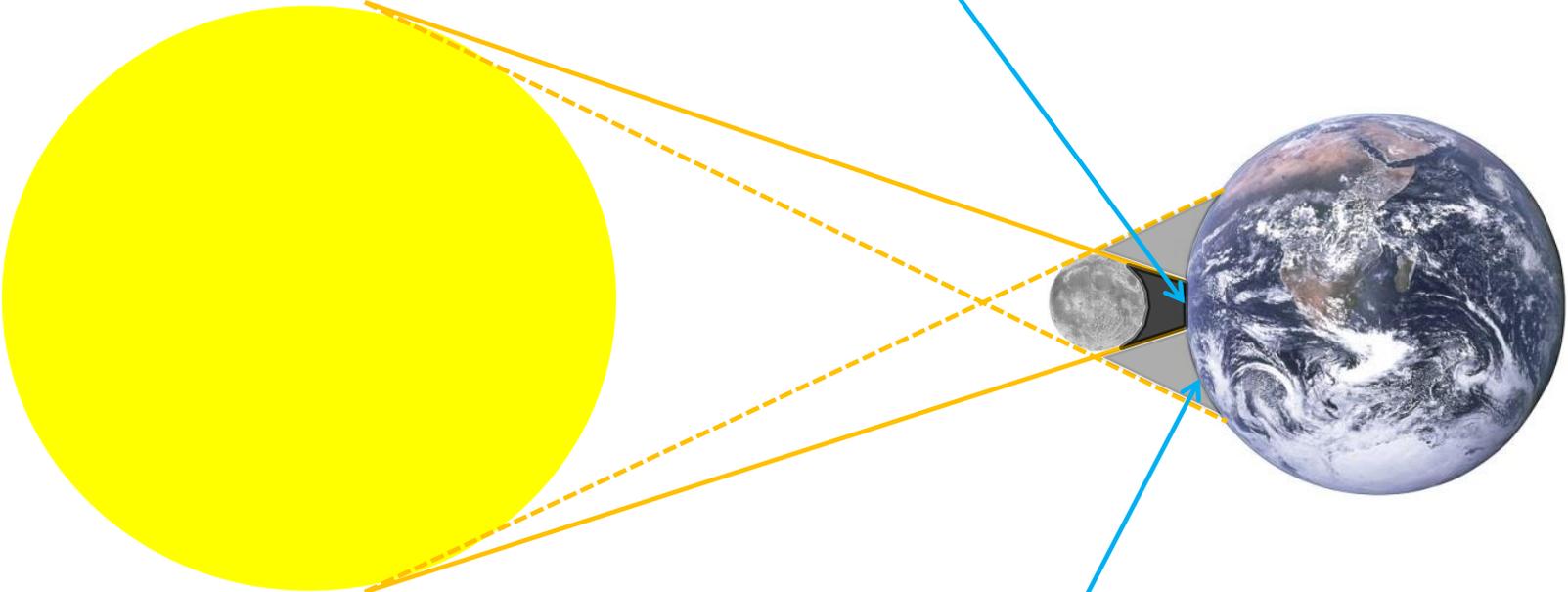
# Hipparchus of Nicaea

190 BC – 120 BC



“On Sizes and Distances”

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 $D_m$

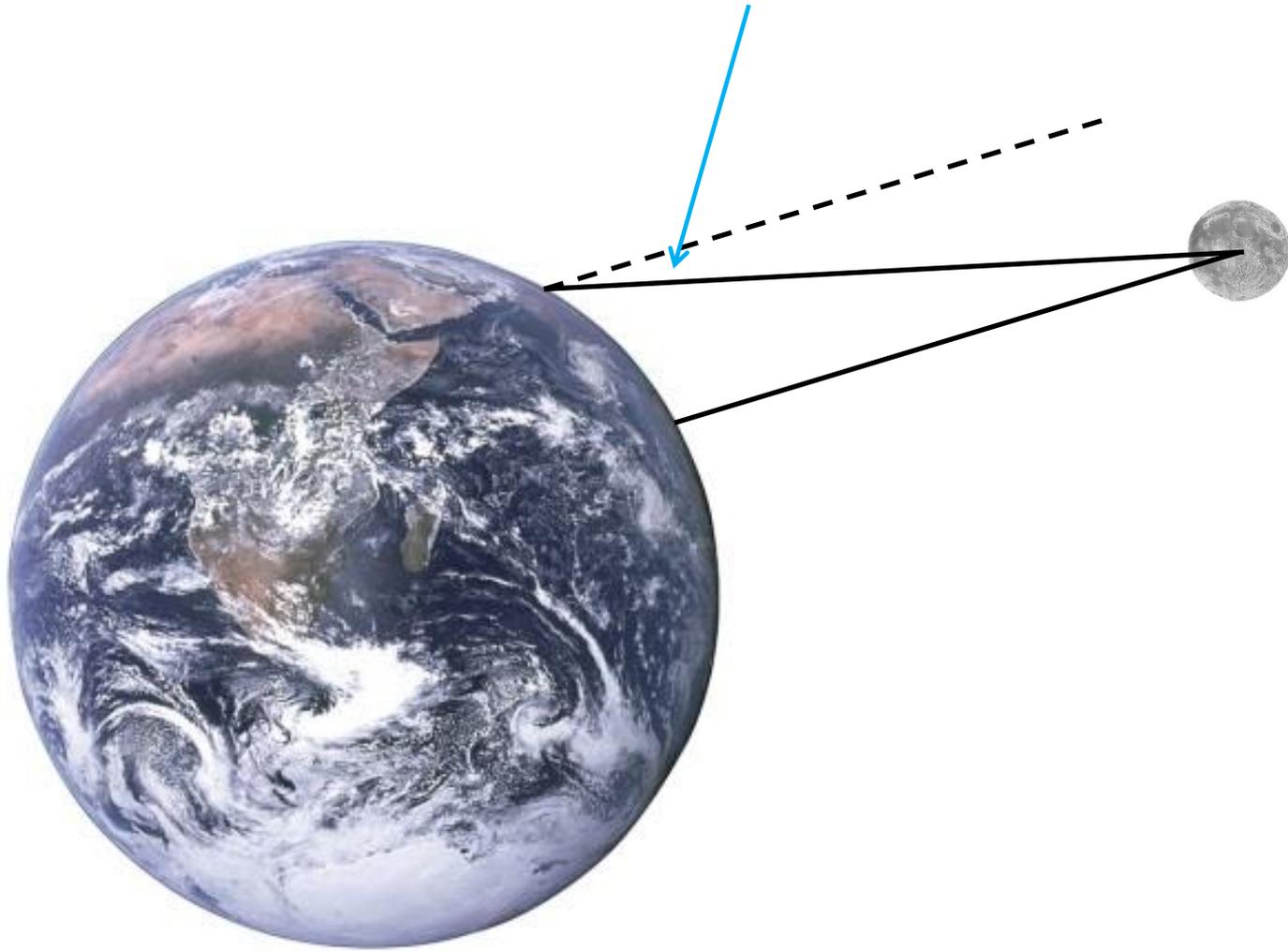
# Claudius Ptolemy

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 $D_m$

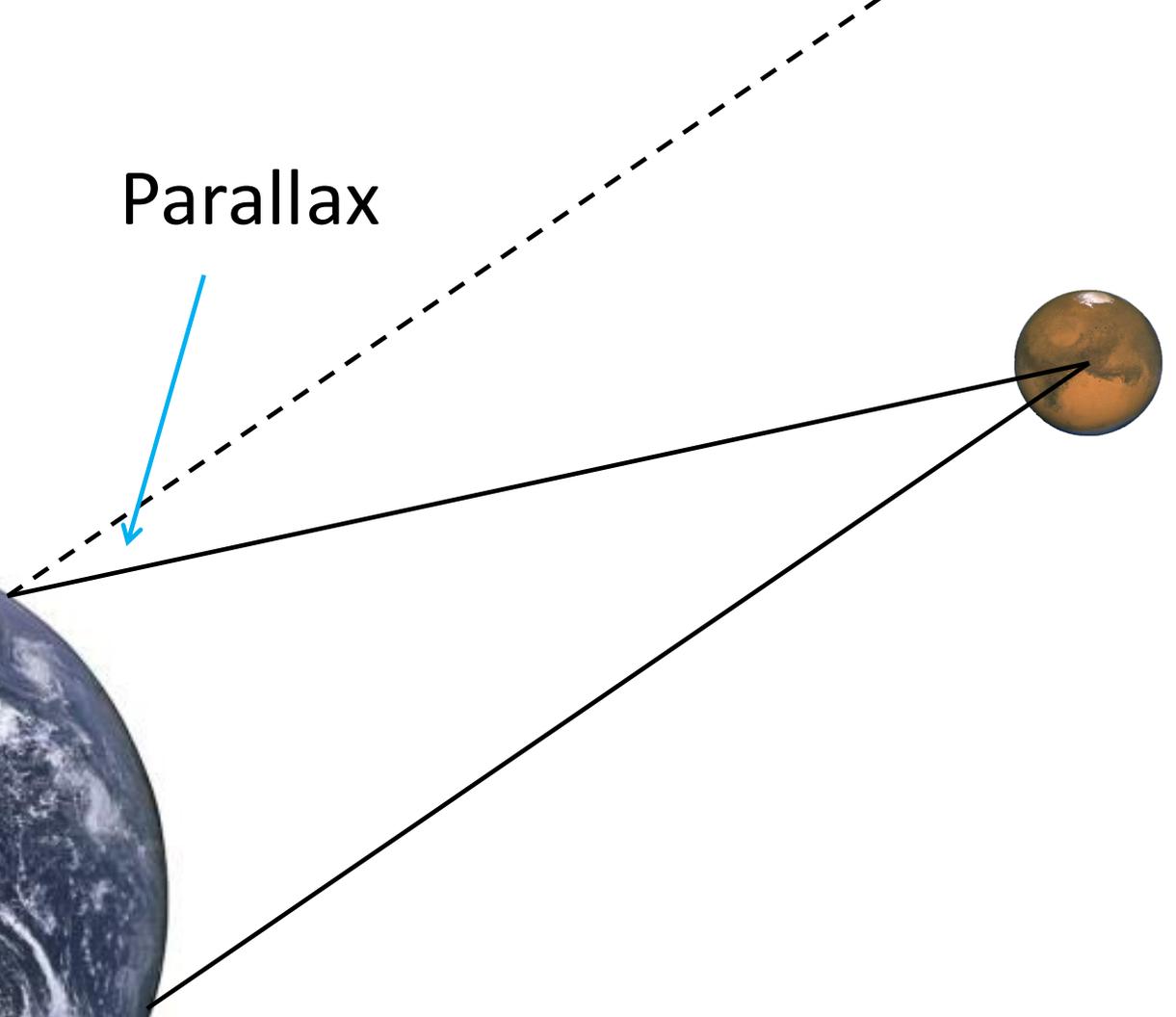
Giovanni Domenico Cassini  
1625-1712 AD



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 $D_m$

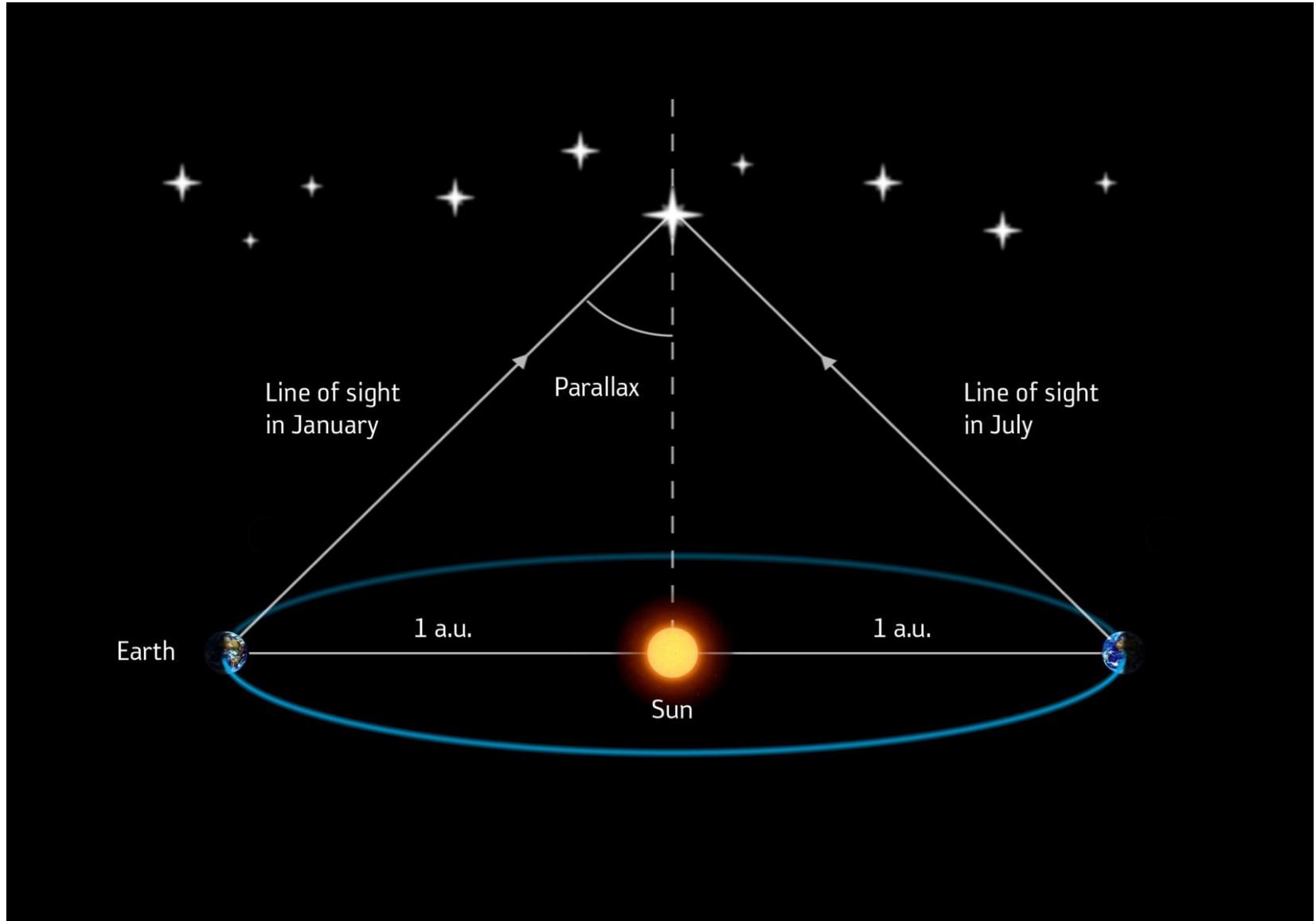
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Me	2025 AD	62 $R_e$	40 $D_m$

	Year	Distance to Moon	Distance to Sun
	Today	60.3 $R_e$	389 $D_m$
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Ptolemy	150 AD	59 $R_e$	21 $D_m$
Cassini and Richer	1670 AD		364 $D_m$
Me	2025 AD	62 $R_e$	40 $D_m$
You	Next eclipse		

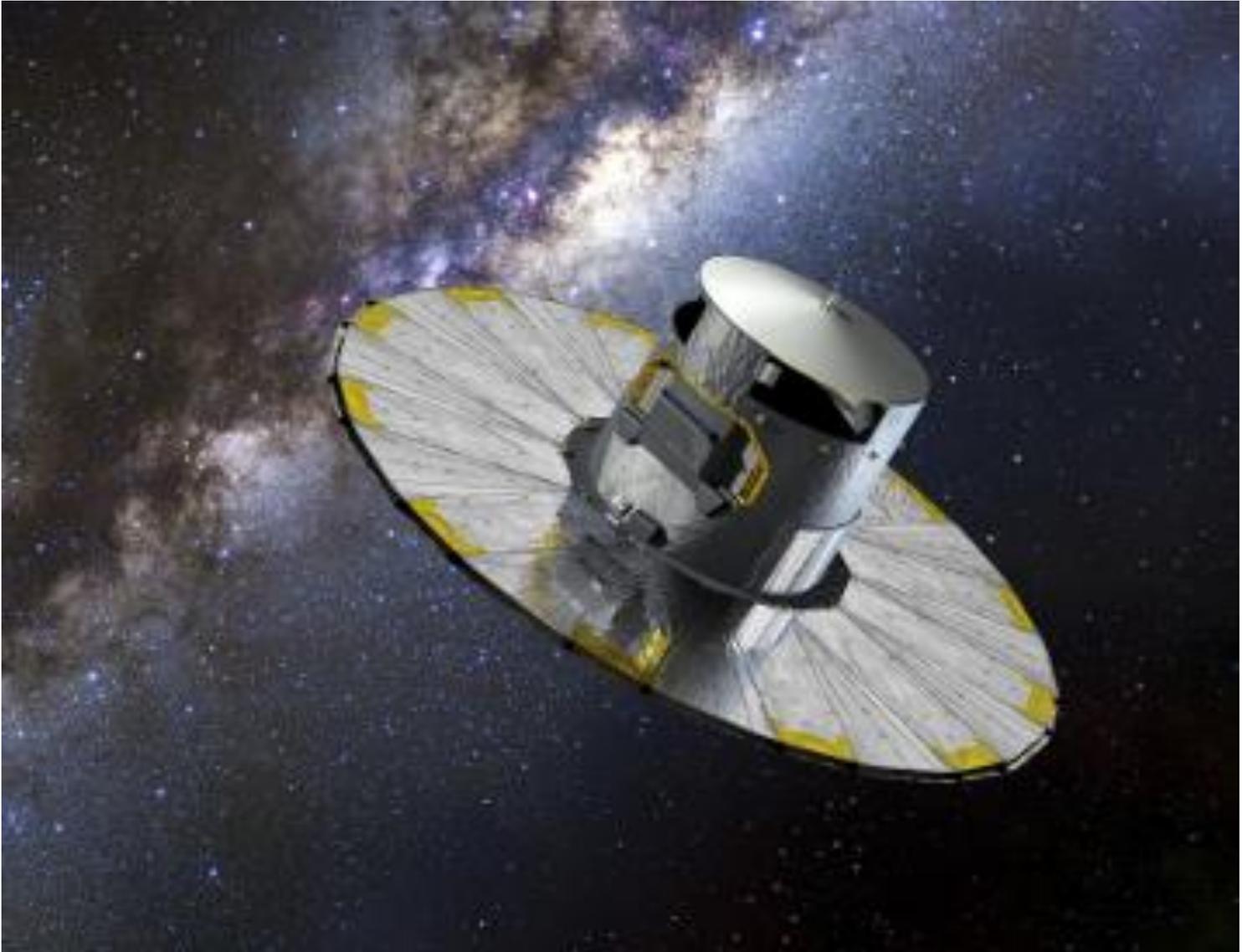
# Other Ancient Discoveries

- **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*



*Gaia* is measuring the position and motion of **1.5 billion** stars