



**From galaxies to planets:
how astronomical images have
revolutionized our understanding
of the Universe**

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Outline

1. A brief history of the telescope.
2. What astronomical images told us about the universe.
3. Where is the future taking us

Telescopes

A telescope is a device that collects photons emitted by astronomical objects across the electromagnetic spectrum

Telescopes

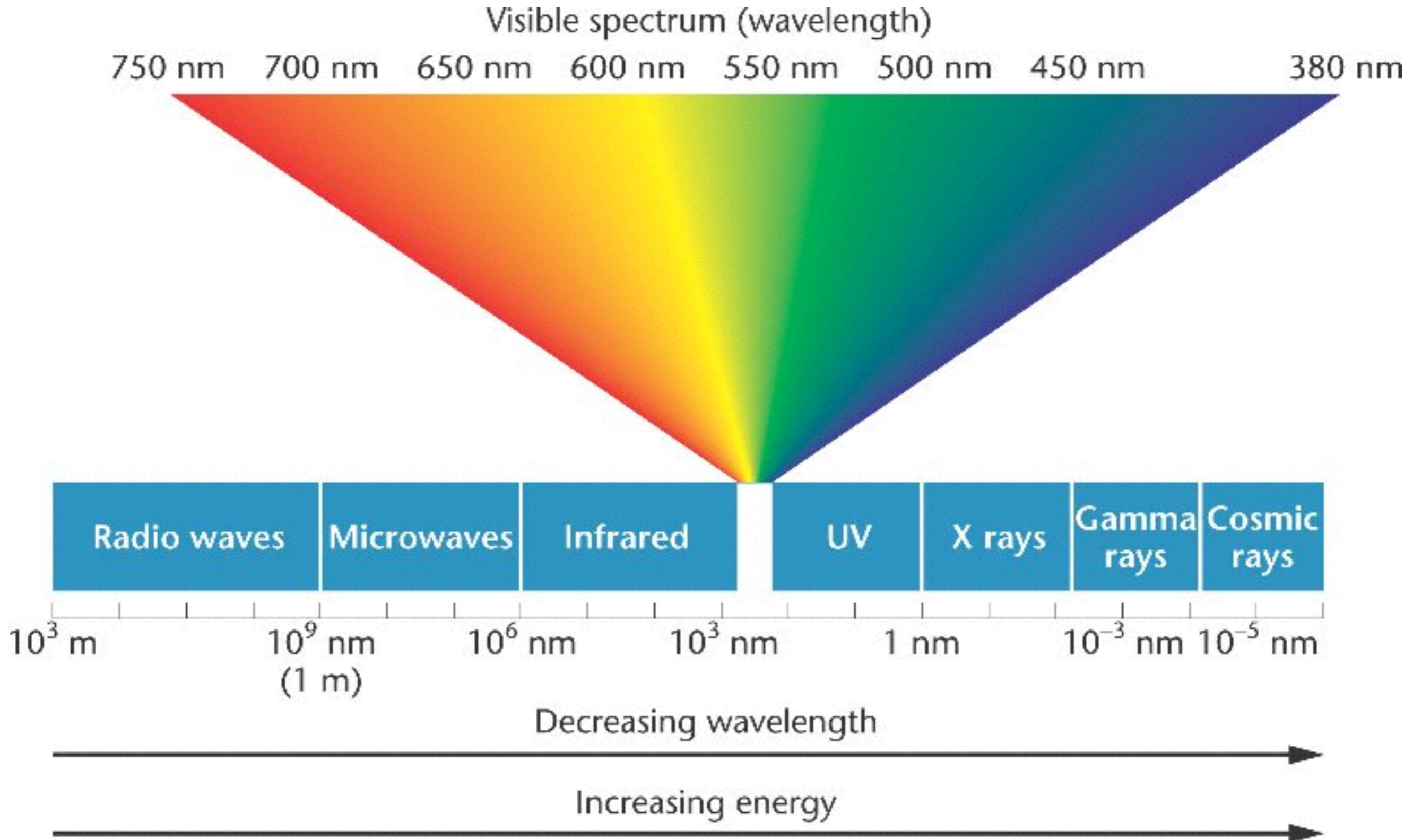


A telescope is a bit like a bucket for collecting rain water.

Bigger buckets collect more rain.

Bigger telescopes collect more photons.

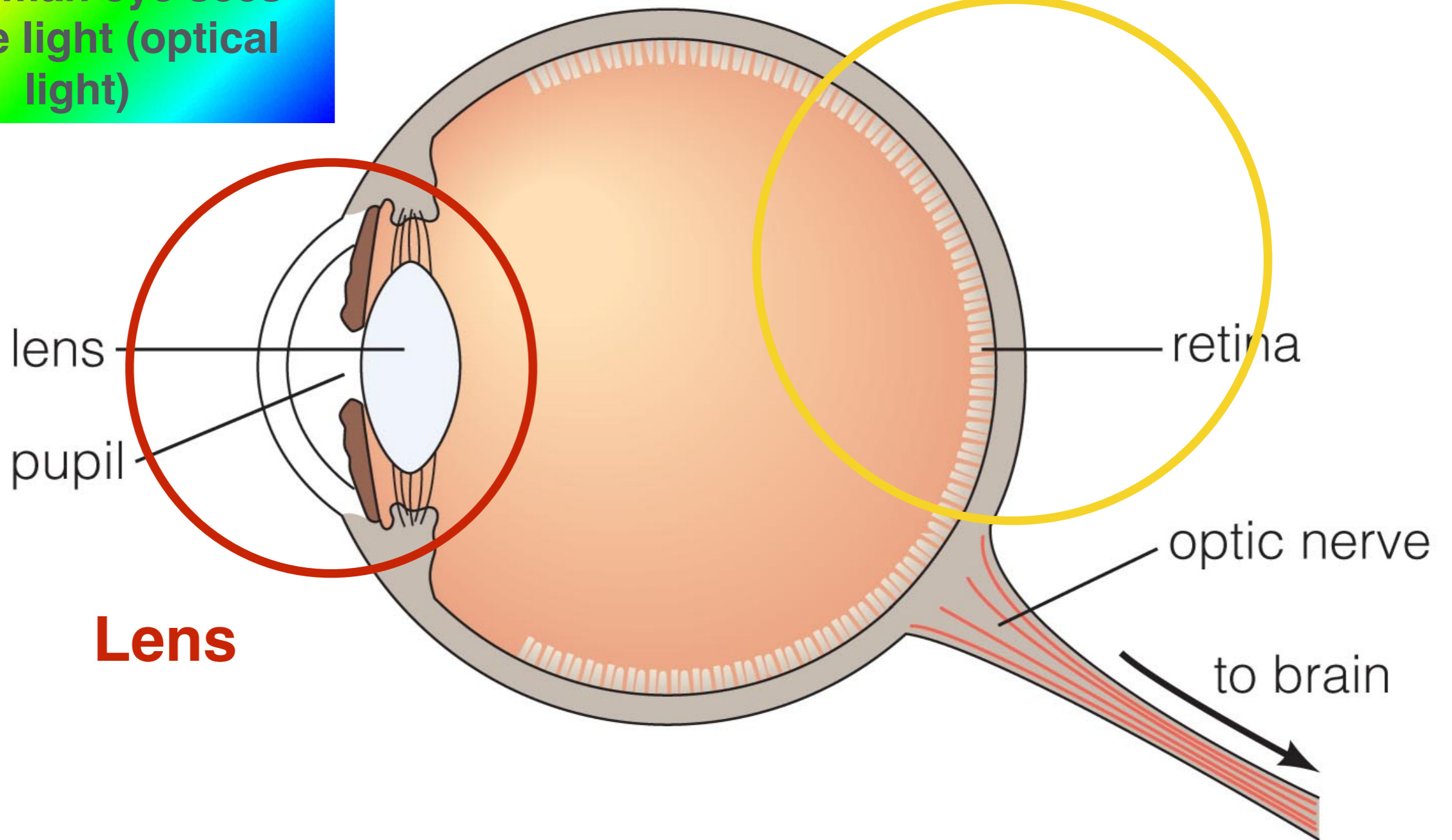
Electromagnetic spectrum



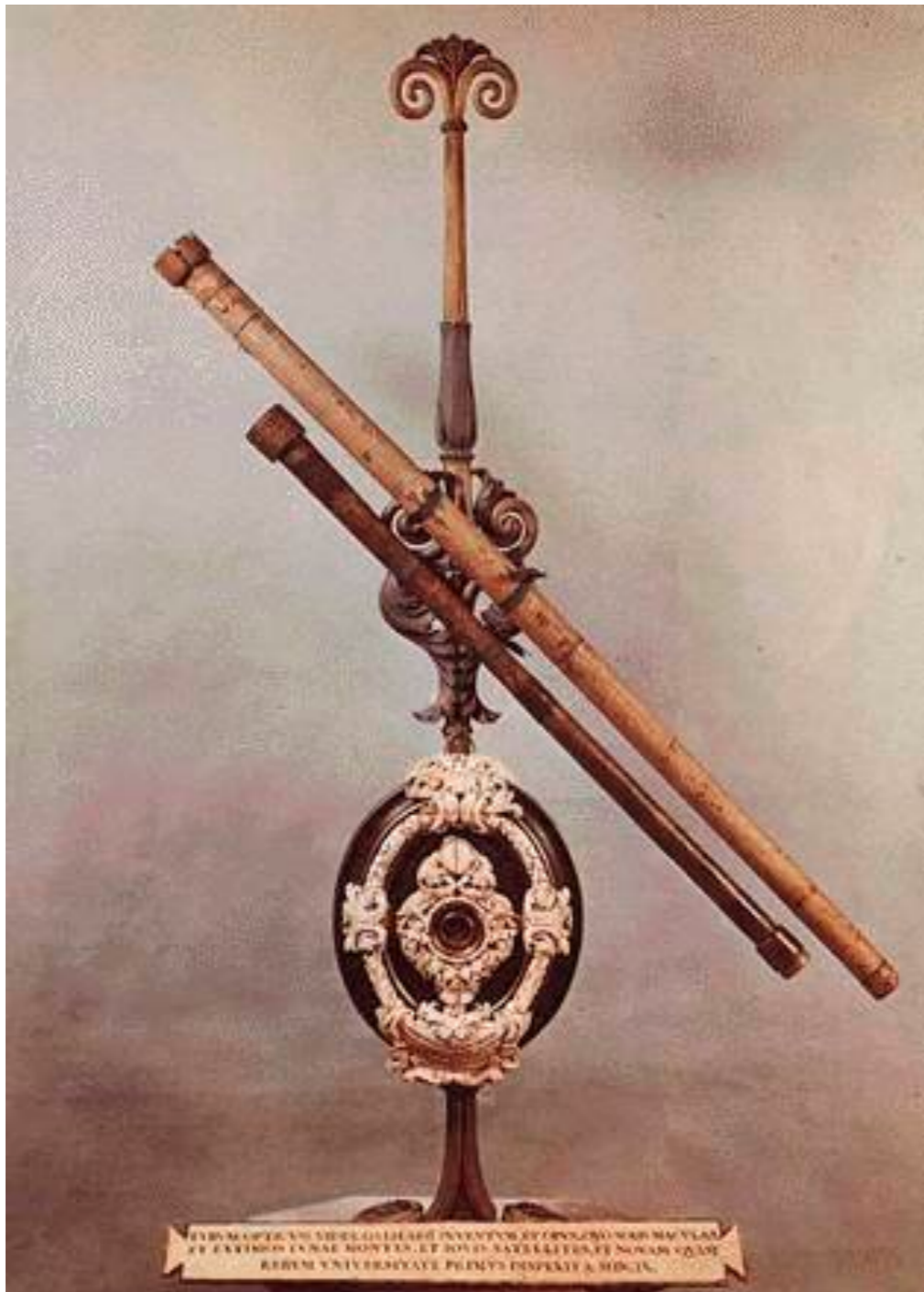
The first telescope: the human eye

the human eye sees
visible light (optical
light)

Sensors or detectors



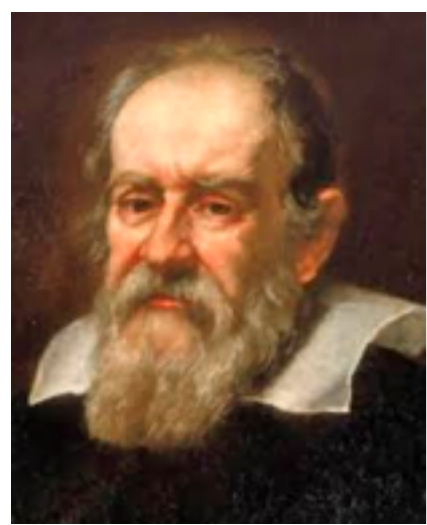
The dawn of modern astronomy



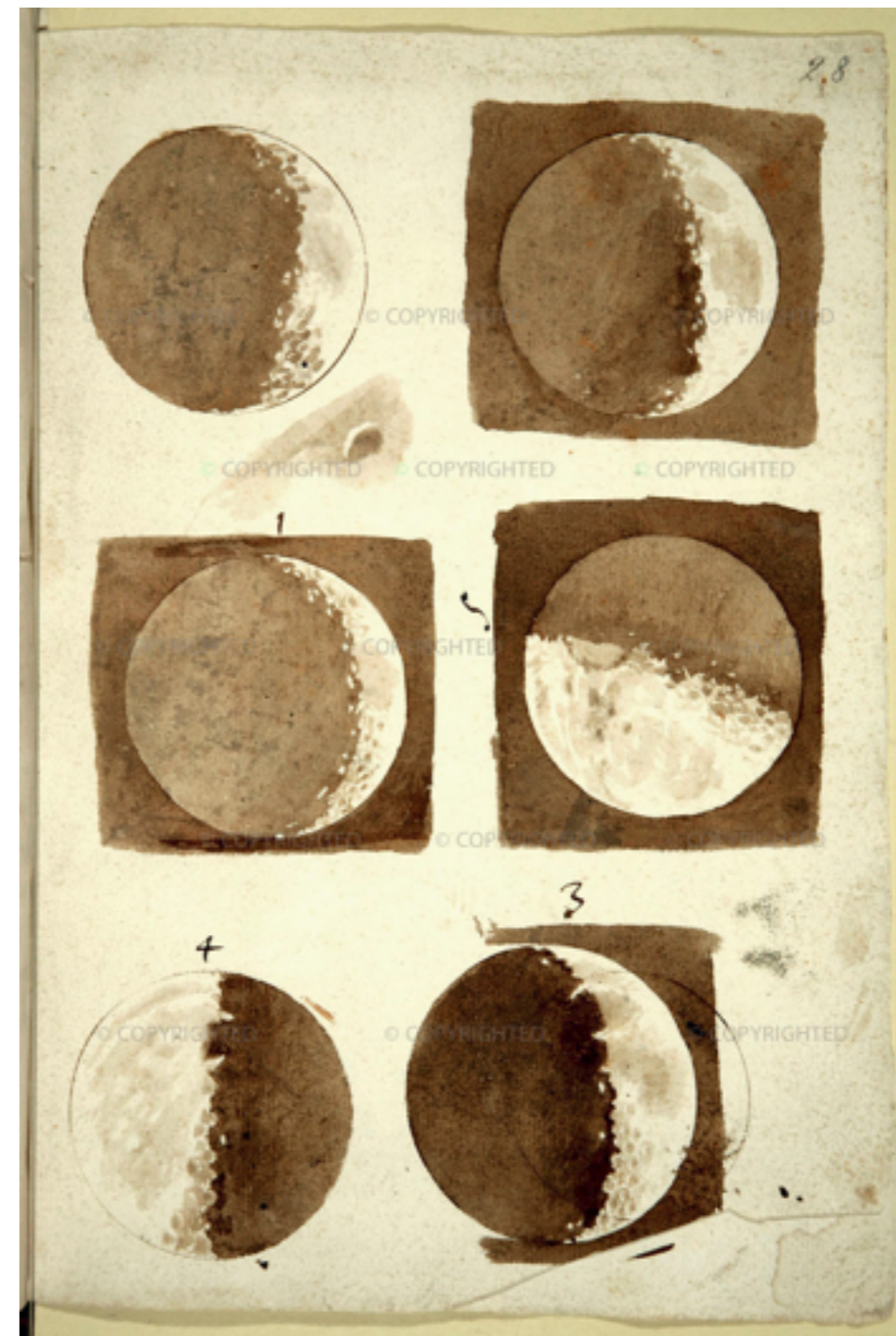
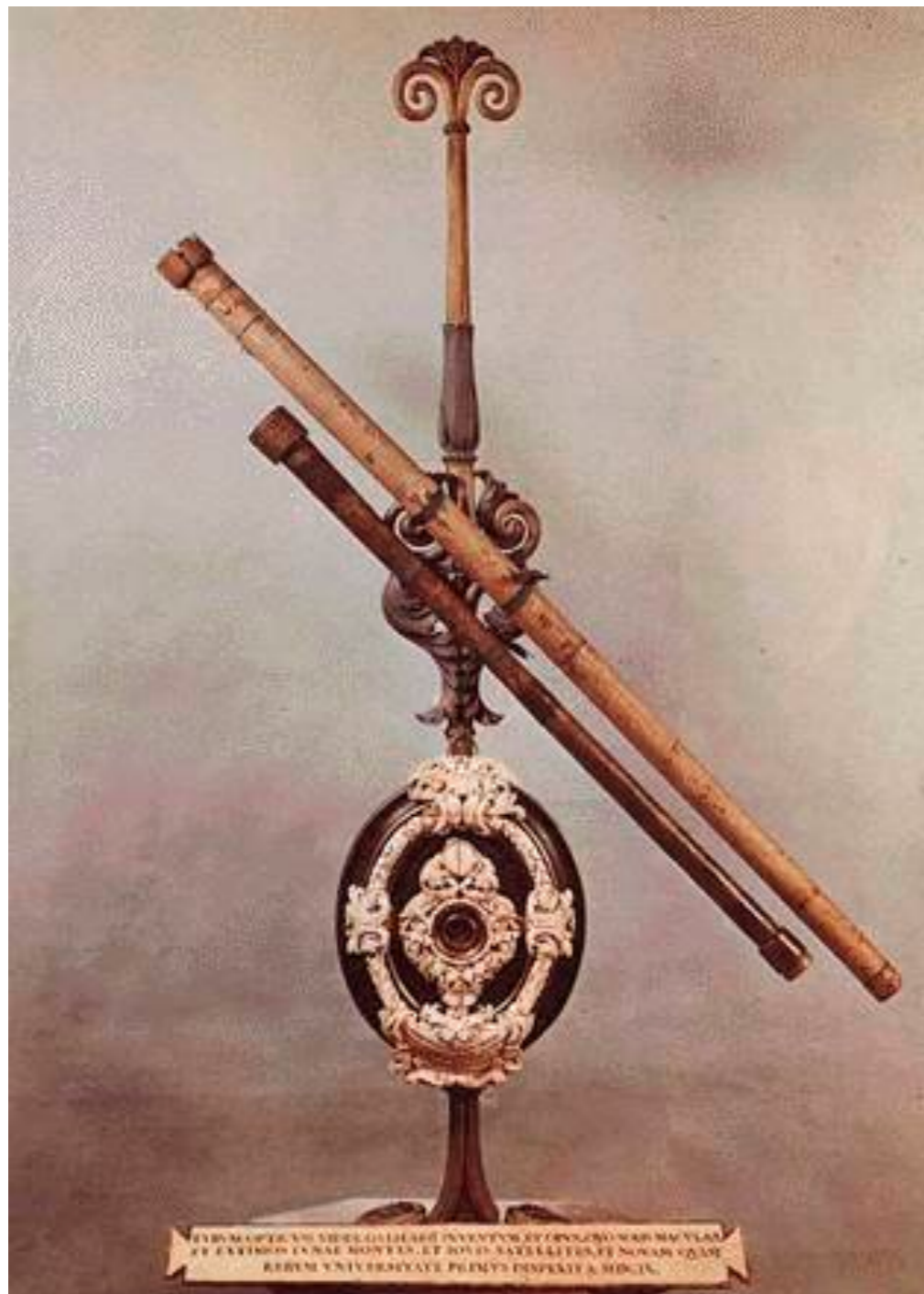
Galileo Galilei
1609 AD

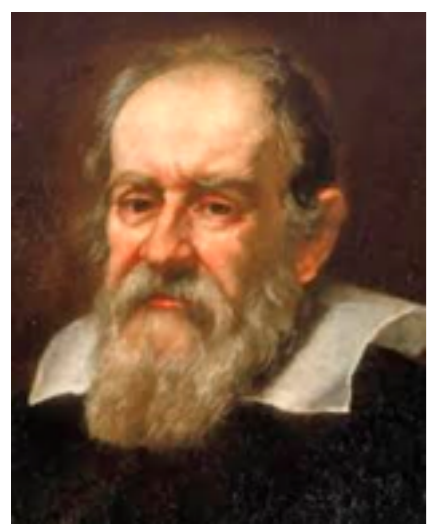
**The first (mechanical)
telescope!**

The diameter of Galileo's telescope was only 37 mm or about 1 1/2 inches!

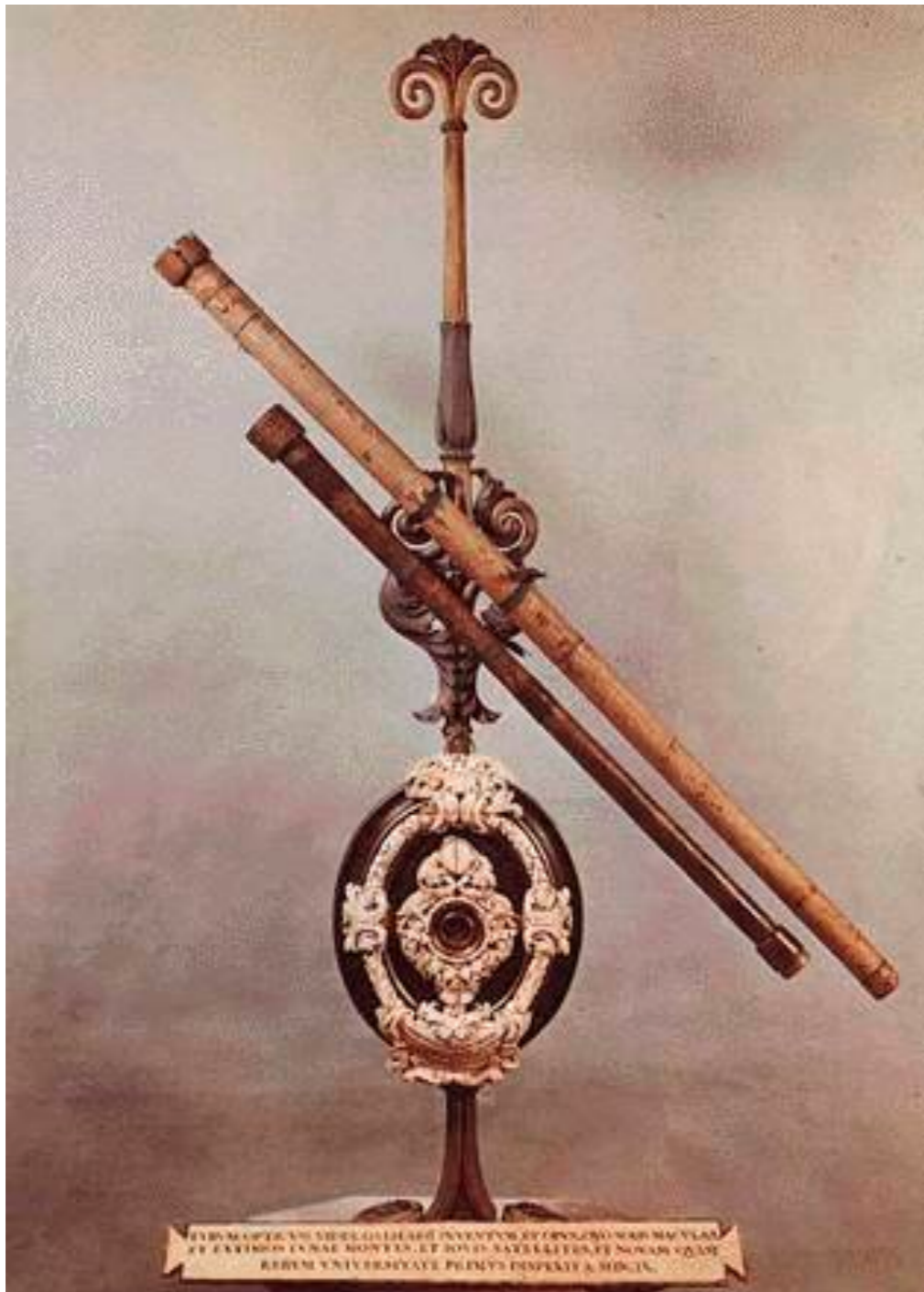


Galileo's drawings





Galileo's drawings

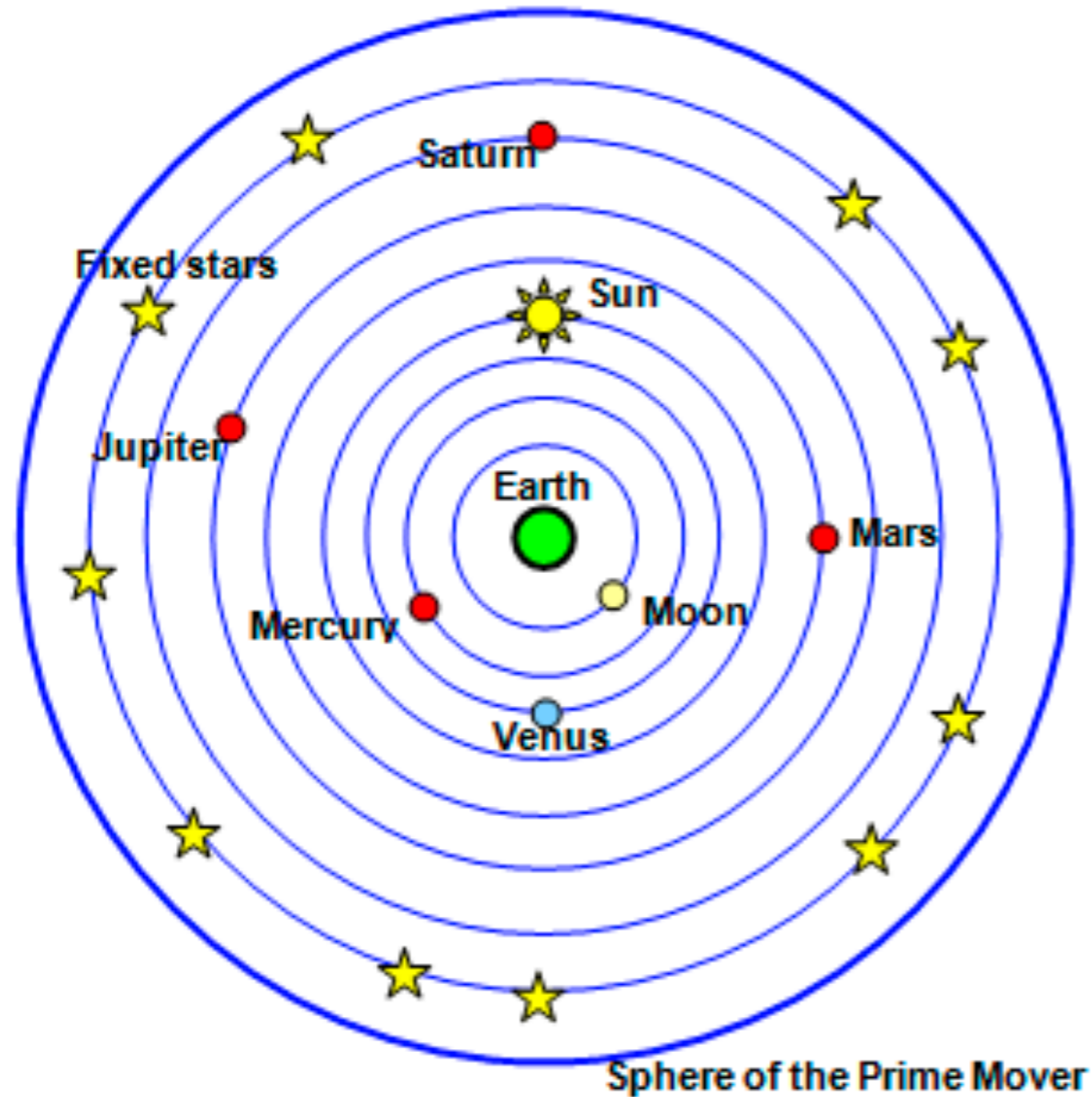


Observationes Jovianae
1610

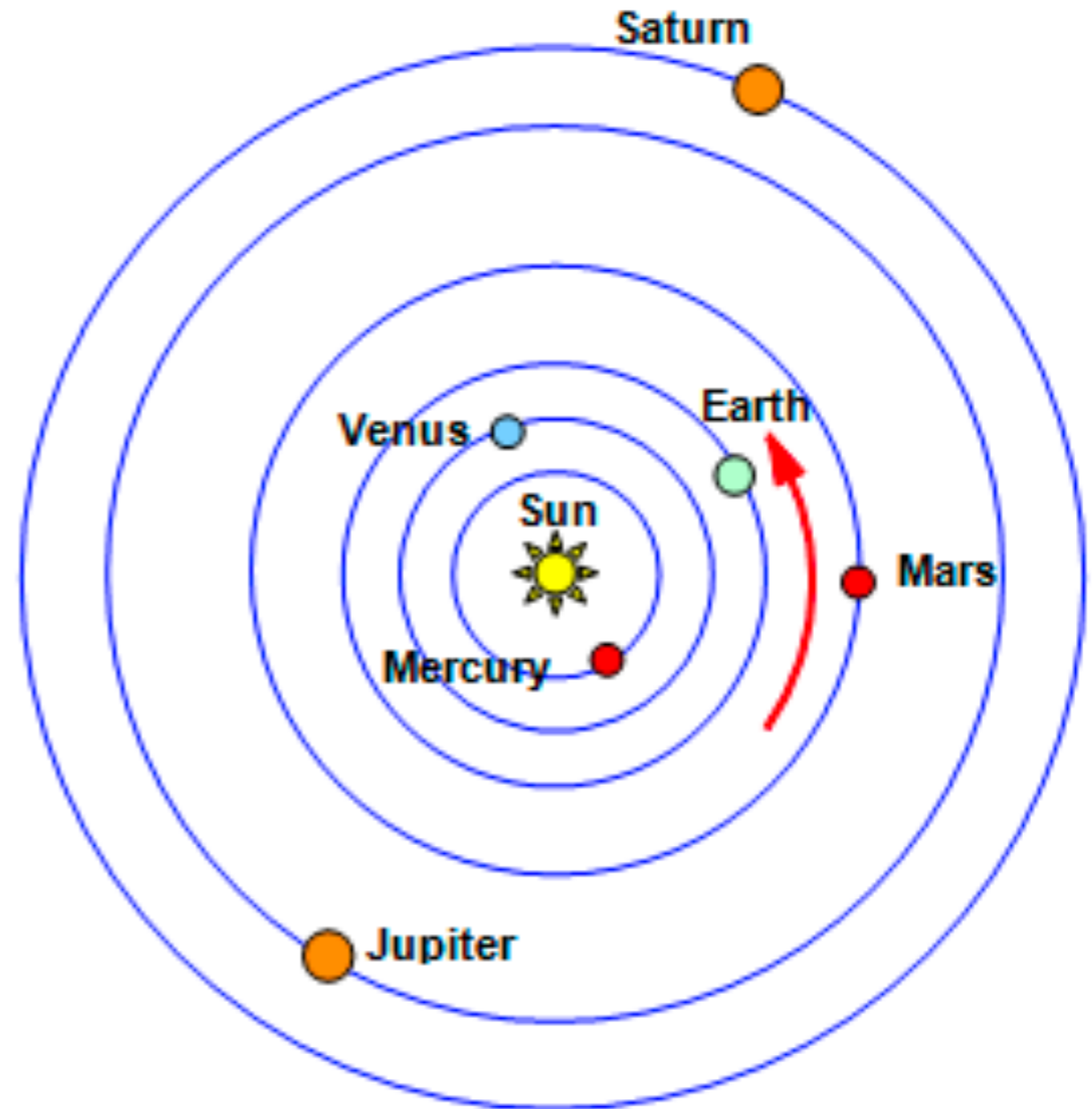
2. p. Jovis. march. 12.	○ * *
30. marc.	* * ○ *
2. apr.	○ * * *
3. marc.	○ * *
3. Ho. J.	* ○ *
7. marc.	* ○ * *
6. marc.	* * ○ *
8. marc. H. 13.	* * * ○
10. marc.	* * * ○ *
11.	* * * ○ *
12. H. 4. sept.	* * ○ *
13. marc.	* * * ○ *
14. Cassi.	* * * ○ *

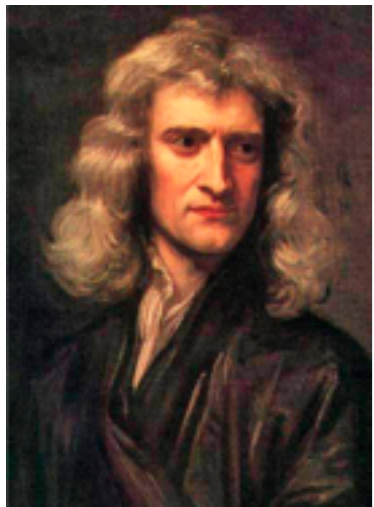
The First Revolution

geocentric model
Aristotele

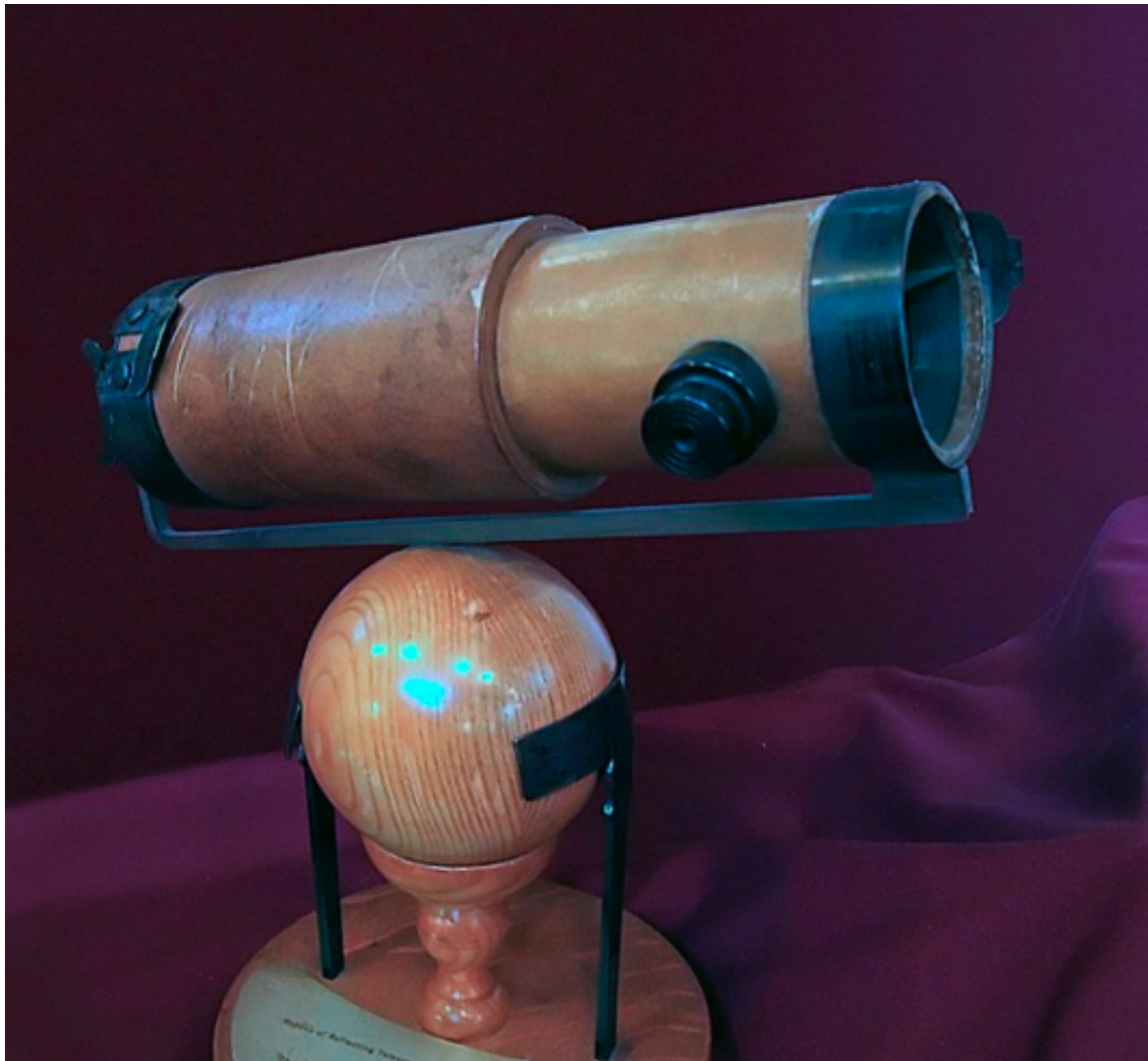


heliocentric model
Copernicus





Isaac Newton: 1668 AD



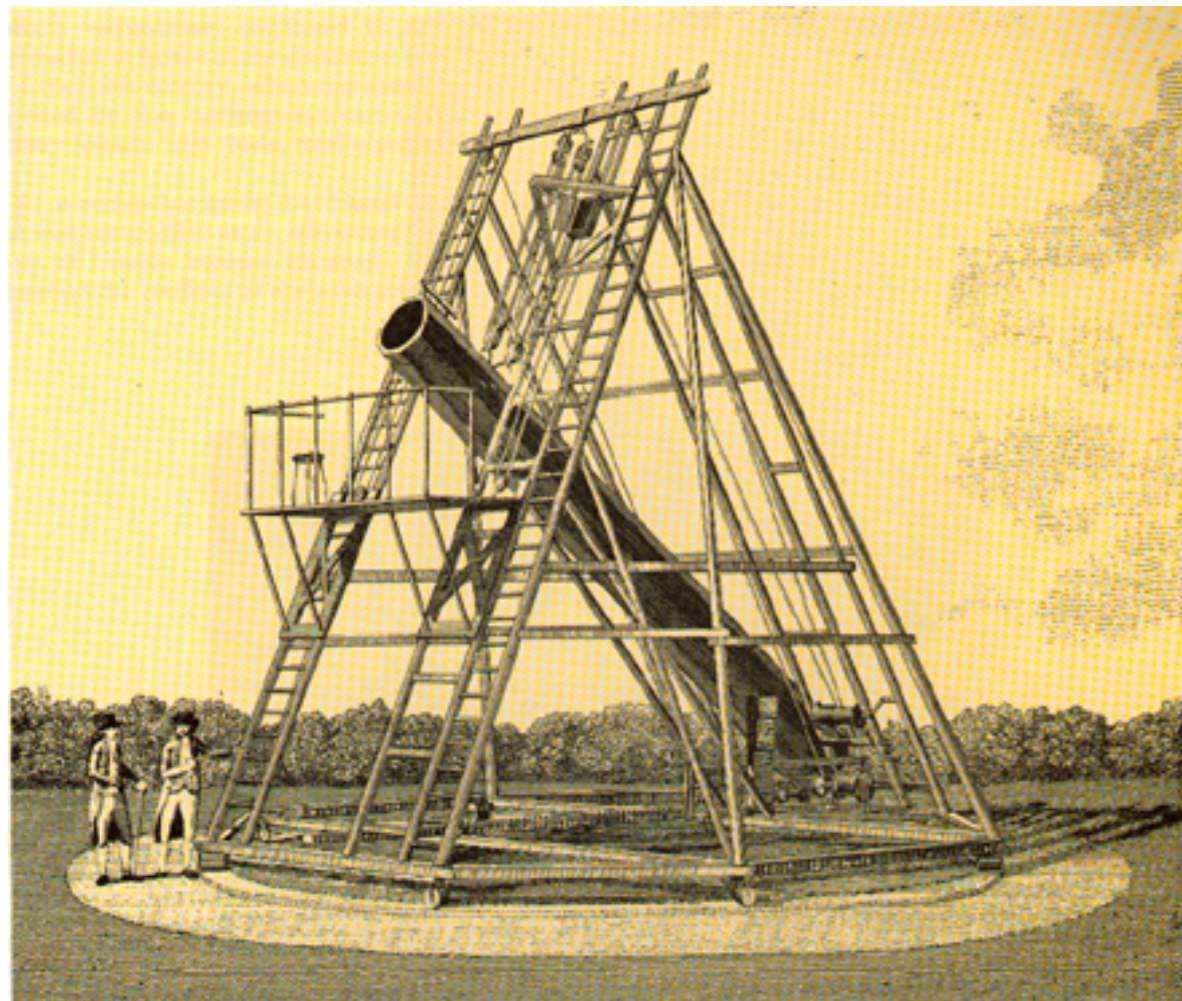
First reflective telescope!

- Cheaper and easier to build.

- Much shorter, less weight.



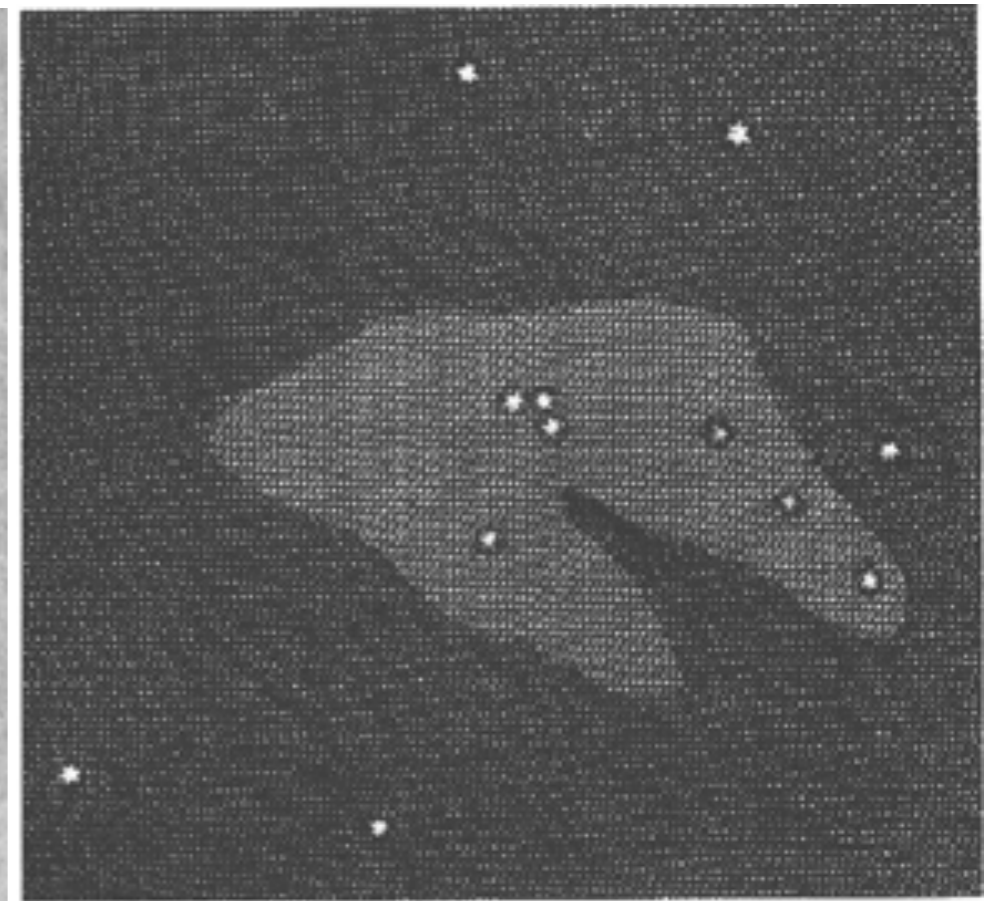
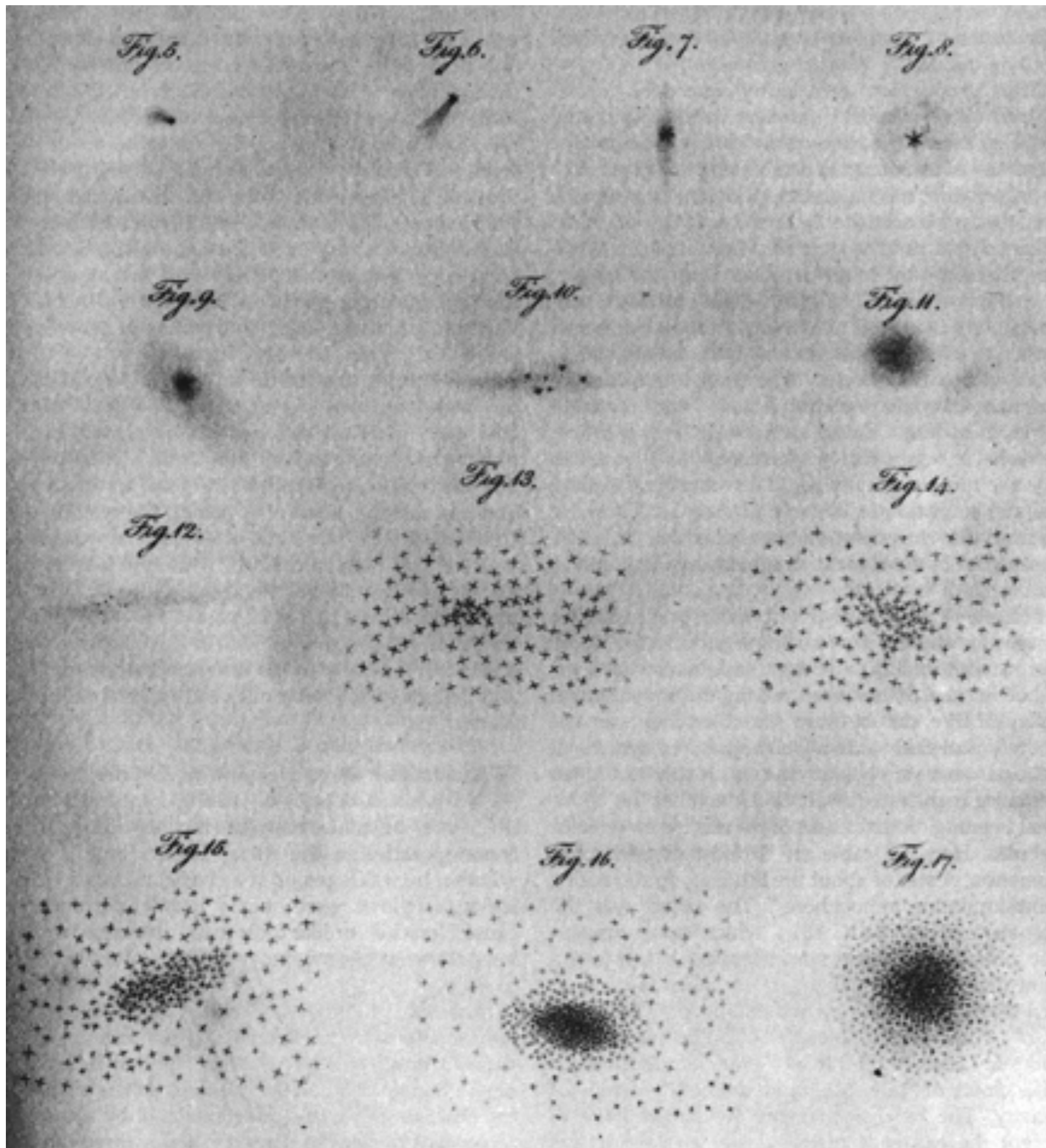
William Herschel: ~1780 AD



First Giant telescope!

- 20 feet long, 18 inches wide,
- Discovery of Uranus and more Saturn's moons
- Discovered thousands of stars and nebulae

(Herschel also discovered infrared radiation)



*Saw the Great Spot in Orion's sword, thro' a 52 fold
 Telescope; its Shape was not as Dr. Smith has
 delineated in his Optics; tho' something resembling
 it; being nearly as follows.*

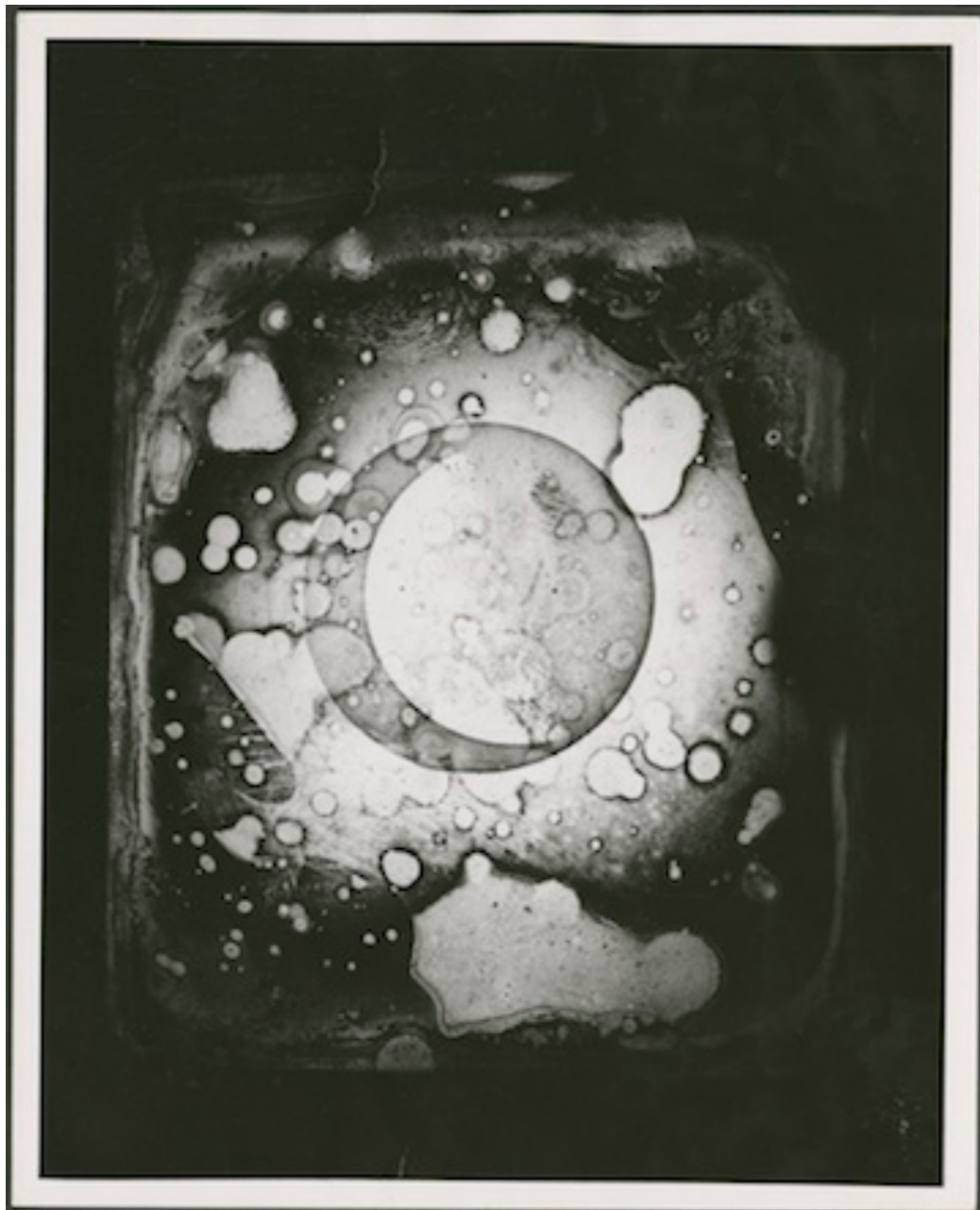


*From this we may infer that there are undoubtedly
 changes among the great stars, and perhaps from a careful
 observation of this spot something might be concluded
 concerning the Nature of it.*

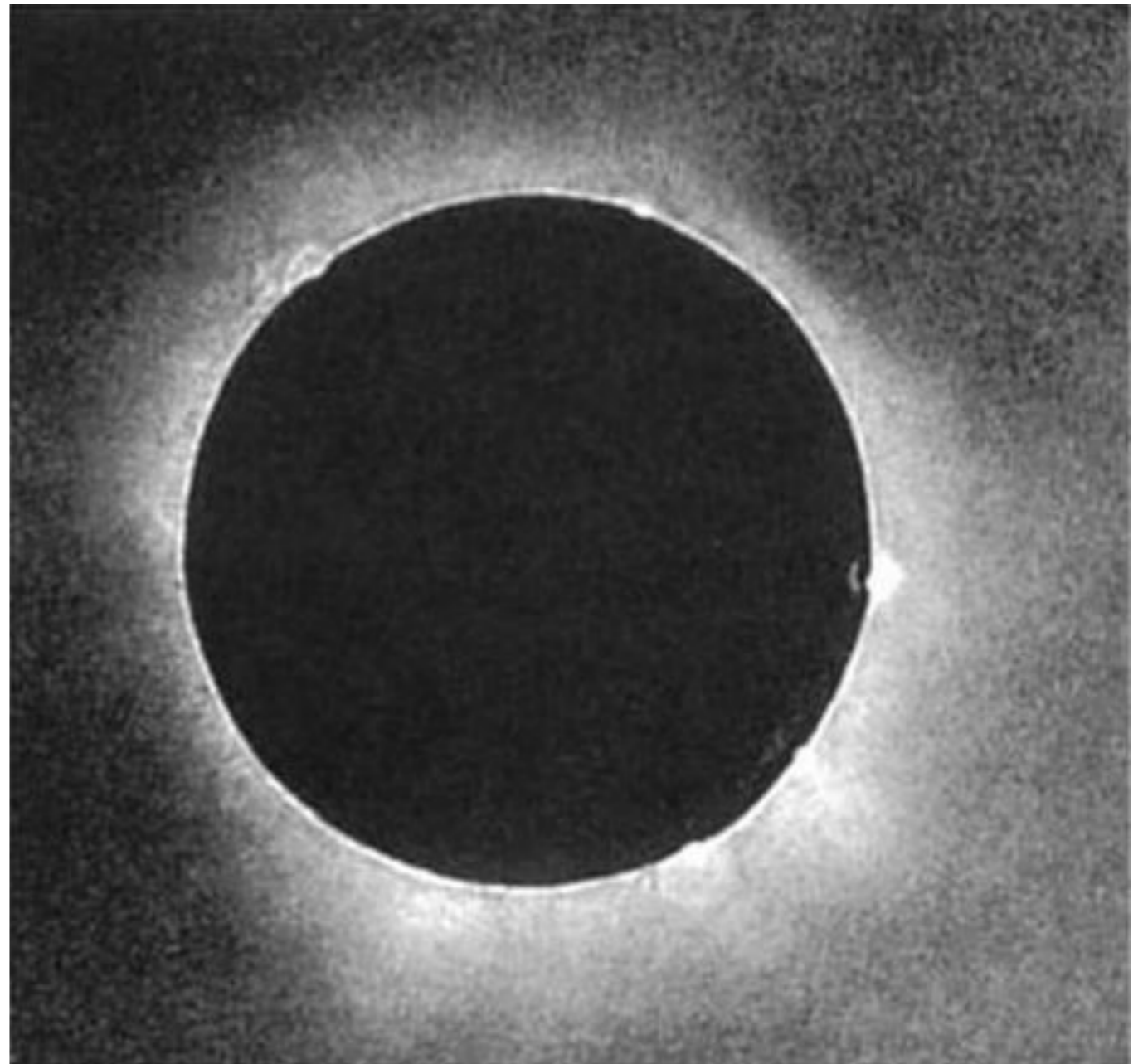
But the human was still the 'detector'

1800 AD: the dawn of (astro)photography

John W. Draper
March 26, 1840



Johann Julius Friedrich Berkowski
July 28, 1851



1800 AD: first pictures of the Orion Nebula

Henry Draper, 1880

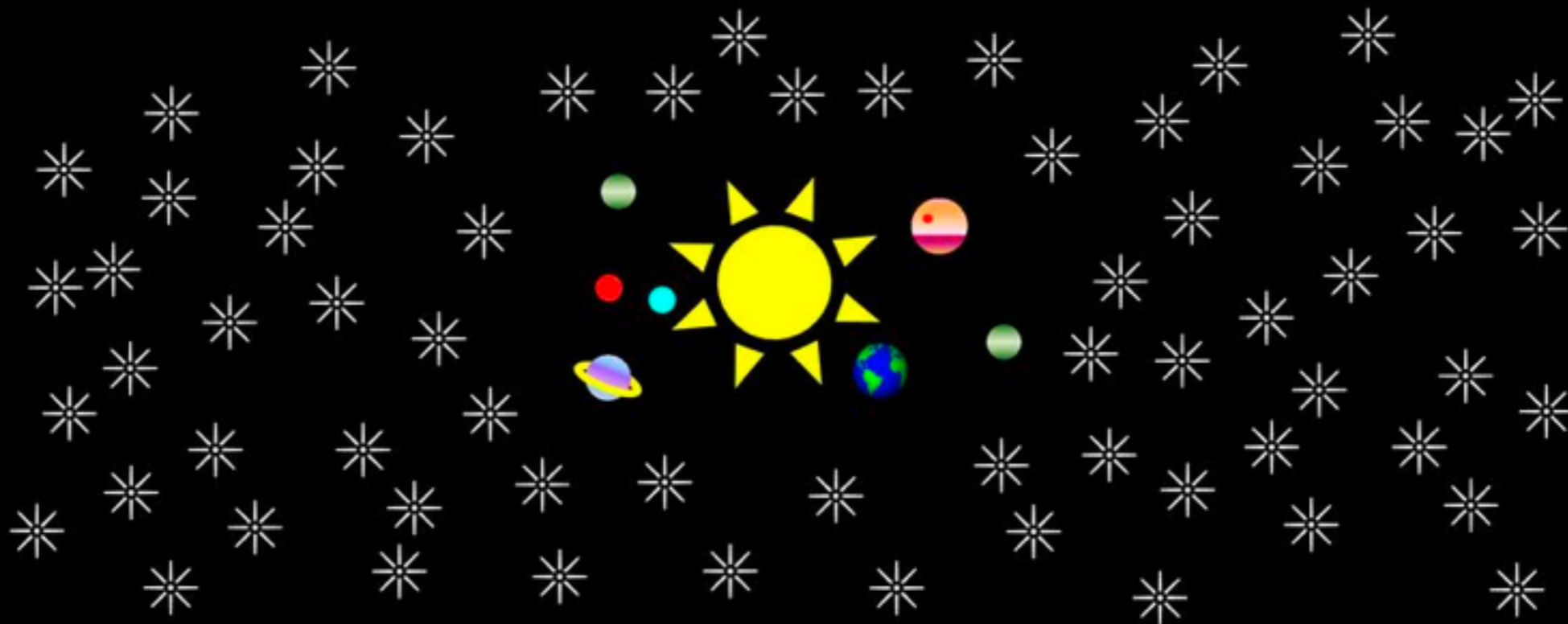


Andrew A. Common, 1883



The universe at the end of the 19th century

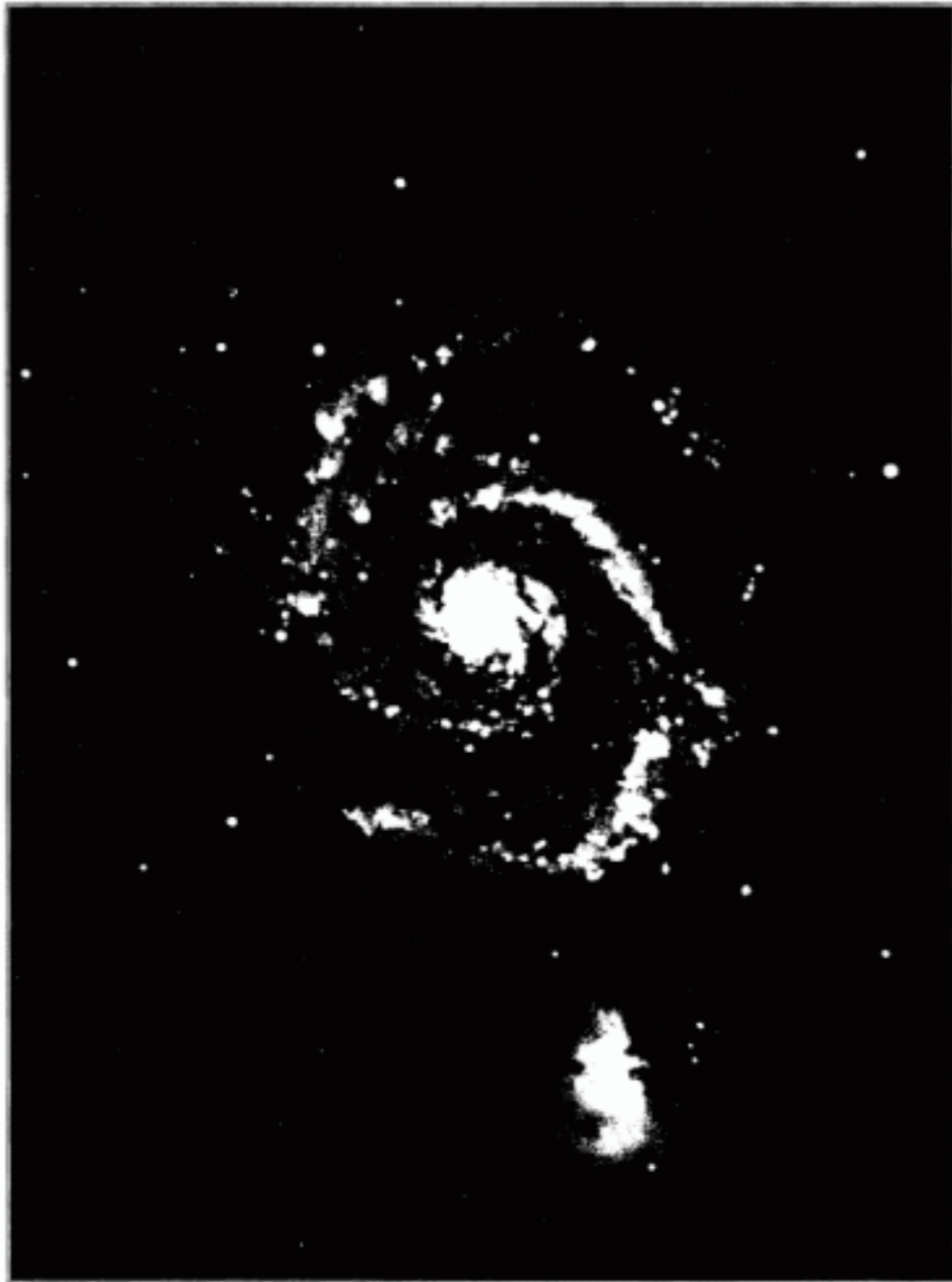
Aside from the few nearby planets and moons, 19th-century scientists thought that the earth and sun were surrounded by infinitely many “fixed stars,” roughly uniformly spaced and extending out to infinity in all directions.



In particular, they thought the universe was static and unchanging. It has existed forever, with no beginning and presumably no end.

credit: R. Trebino

The Great Debate



SPIRAL NEBULA *Messier 51 Canum Venaticorum*
Photographed with 60-Inch Reflector on Seed 23 plate, February 7 and 8, 1910
Exposure 3^h 55^m. Enlargement from negative 6.4 diameters. Scale: 1 mm = 4.72

spiral nebulae were gas cloud
inside of our Galaxy.

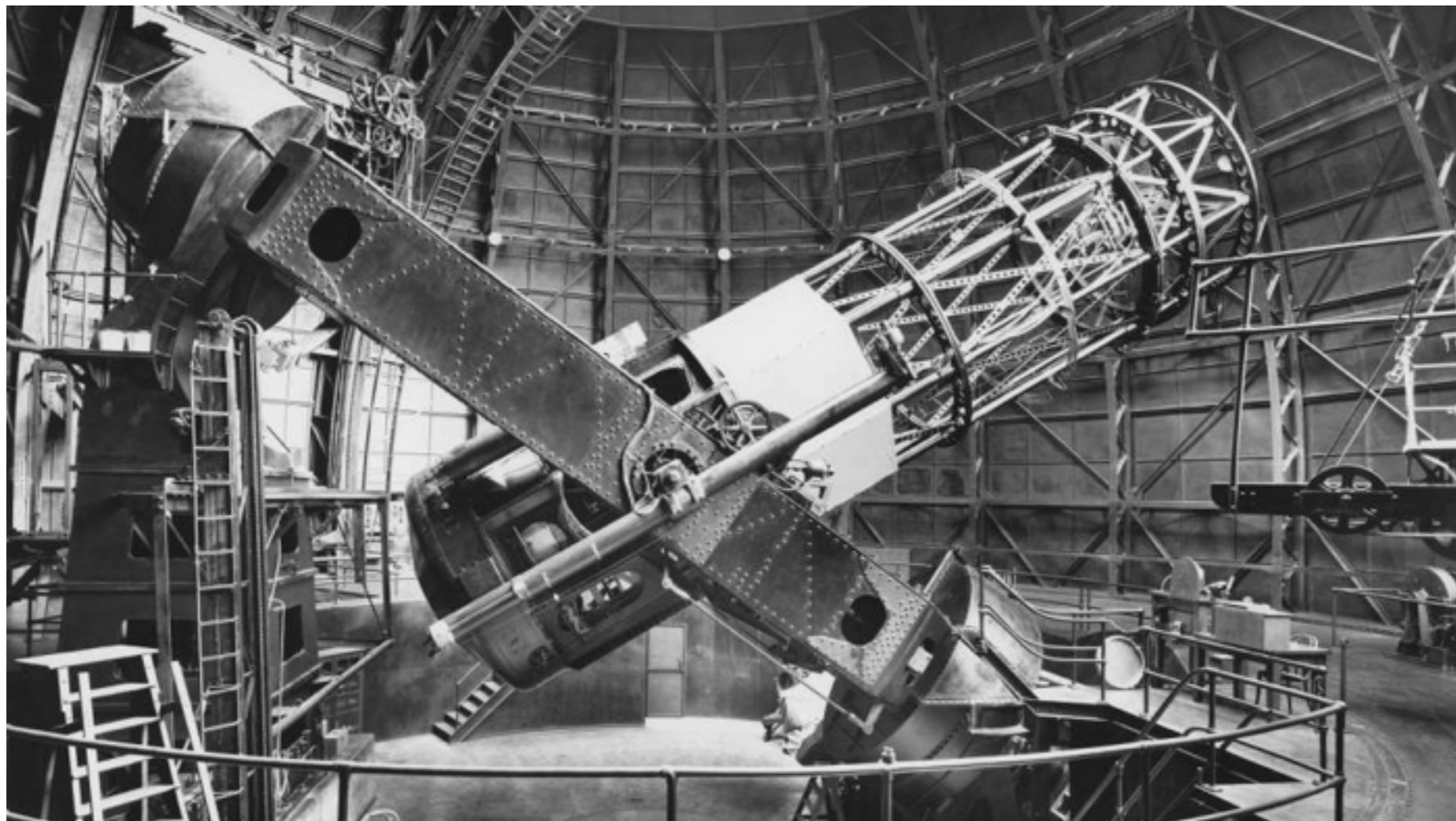
Vs.

spiral nebulae were “island
universes” like the Milky Way,
and they were simply so far
away that their stars were
blurred together so they looked
like a nebula.

The Shapley - Curtis Debate in
1920

The end of the Great Debate

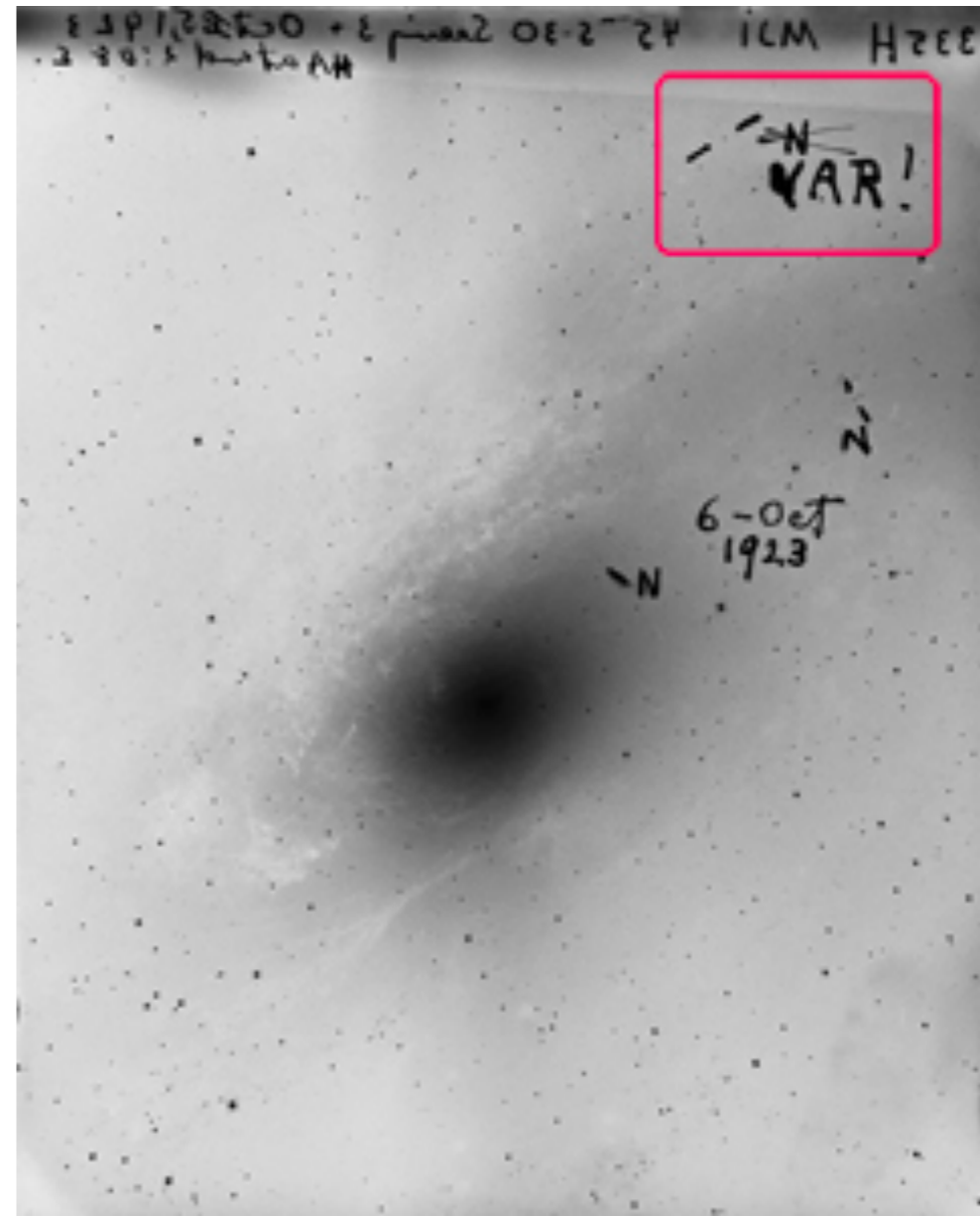
November 1st, 1917: 100-inch telescope on Mount Wilson,
California saw the first light



The end of the Great Debate



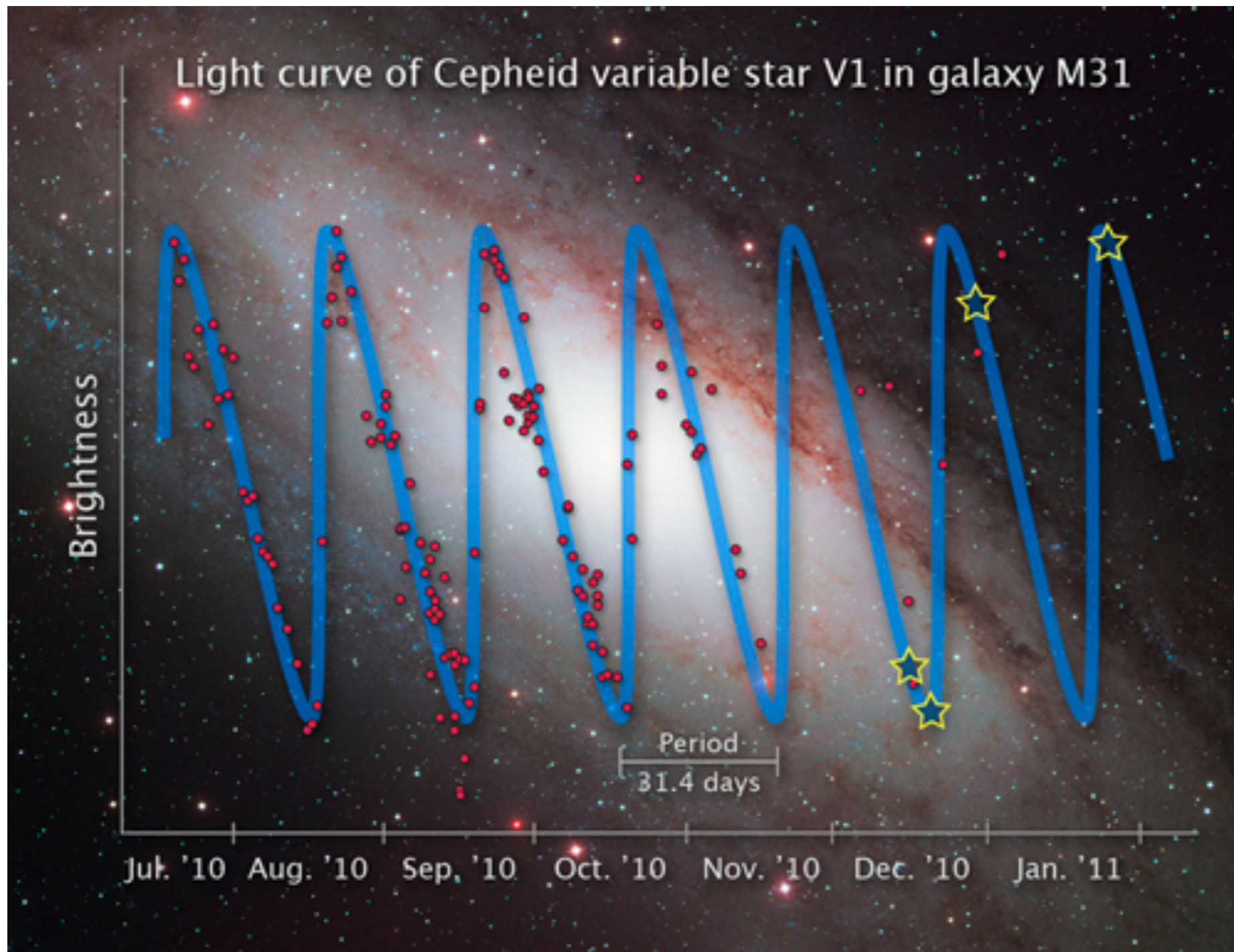
Edwin Hubble



Mt. Wilson Discovery Plate of M31-V1
(Courtesy: Carnegie Observatories)

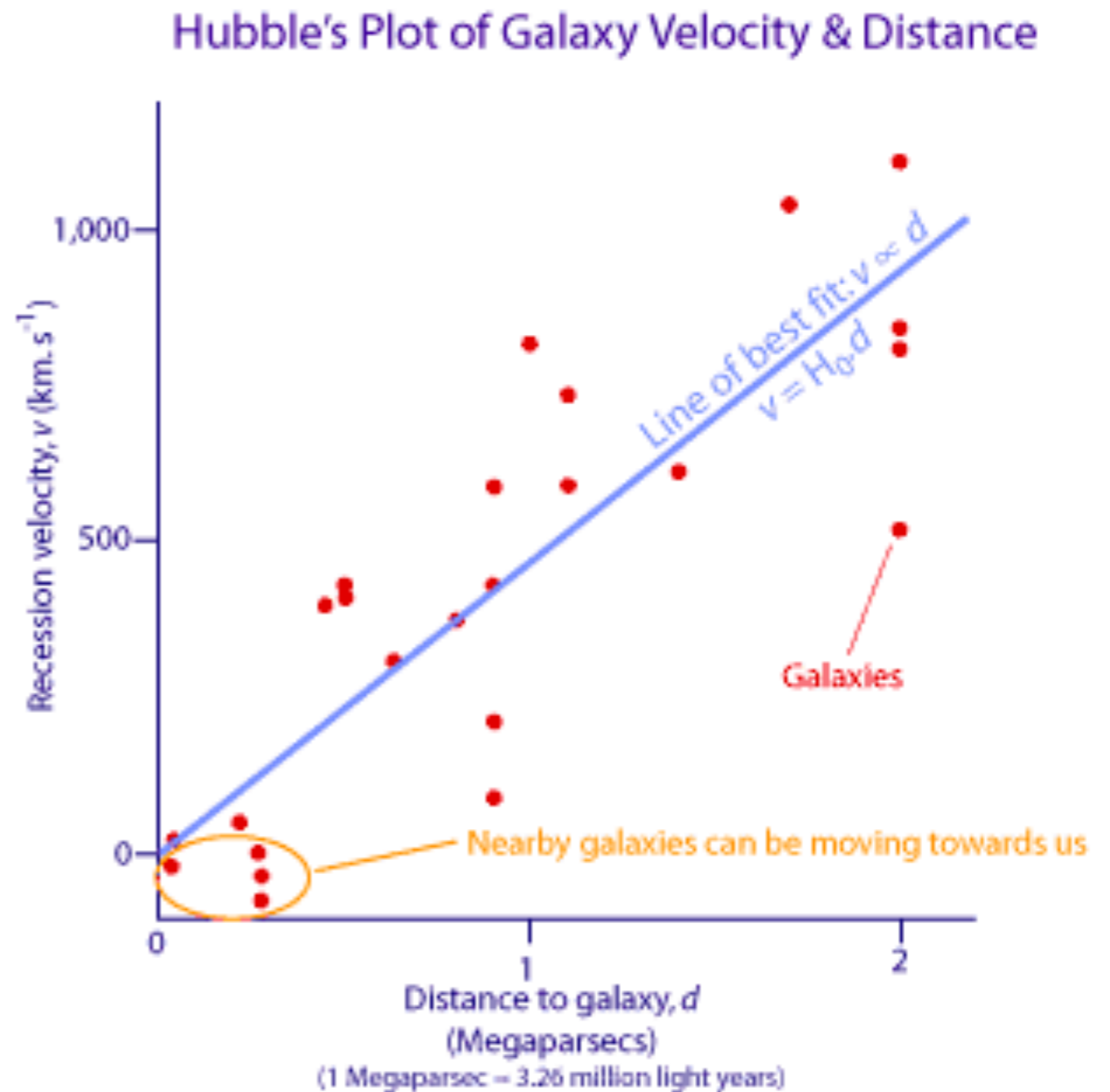
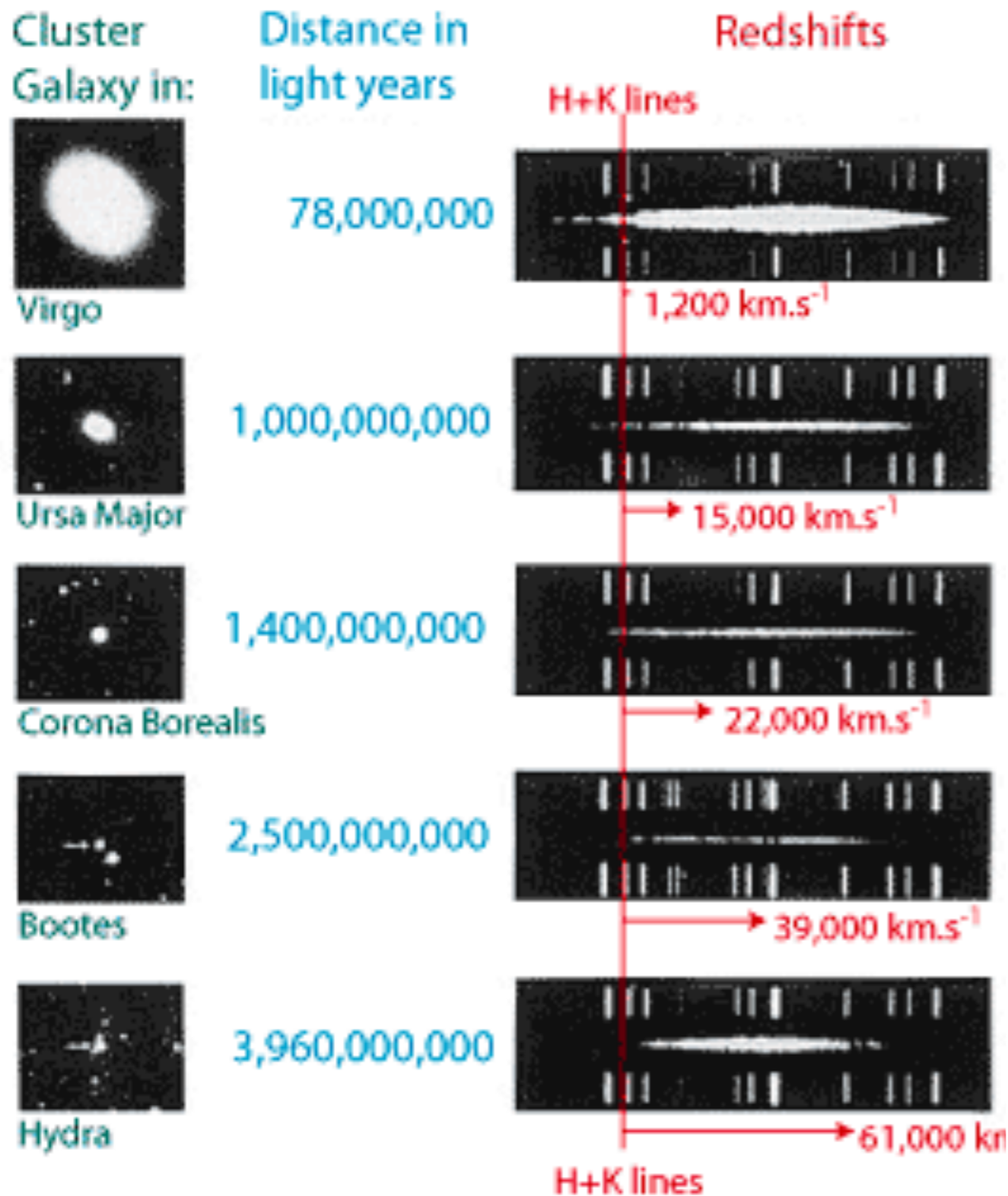
The end of the Great Debate

Oct. 5, 1923



Hubble found that M 31, the Andromeda galaxy, was made of stars and was 900,000 light-years away, outside the Milky Way

Hubble and the expanding Universe: 1929

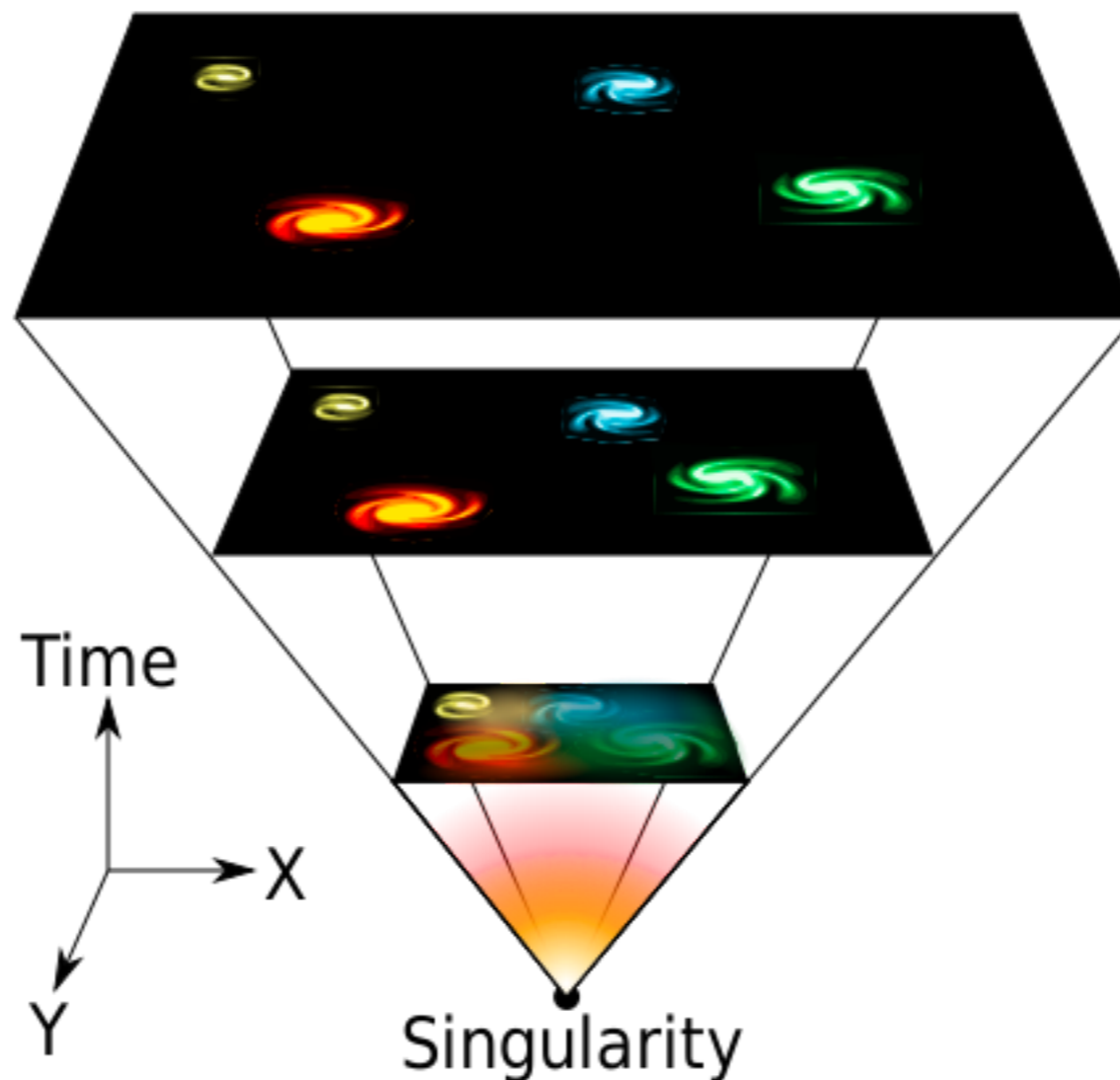


The second revolution: The expanding Universe

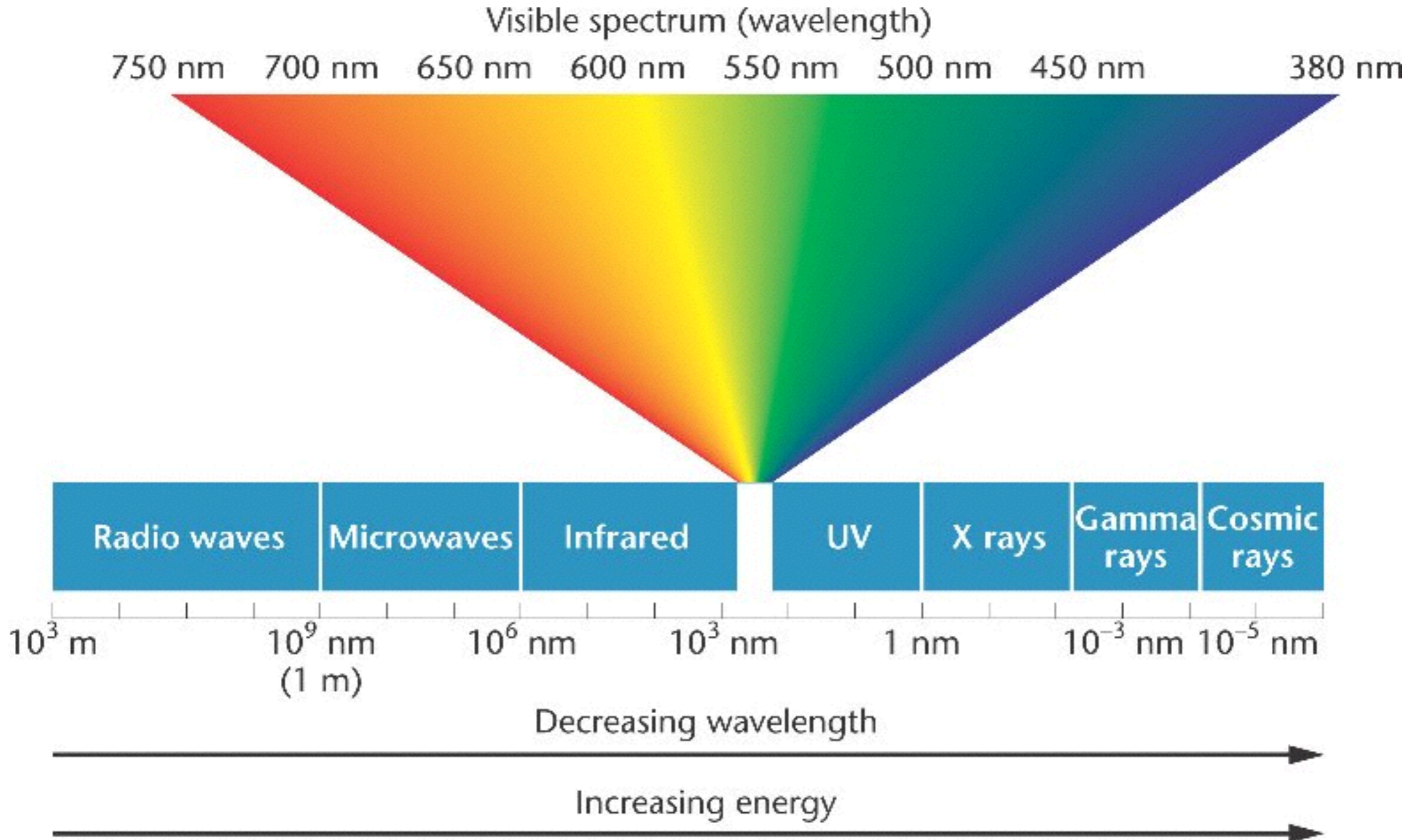


The Big Bang Theory

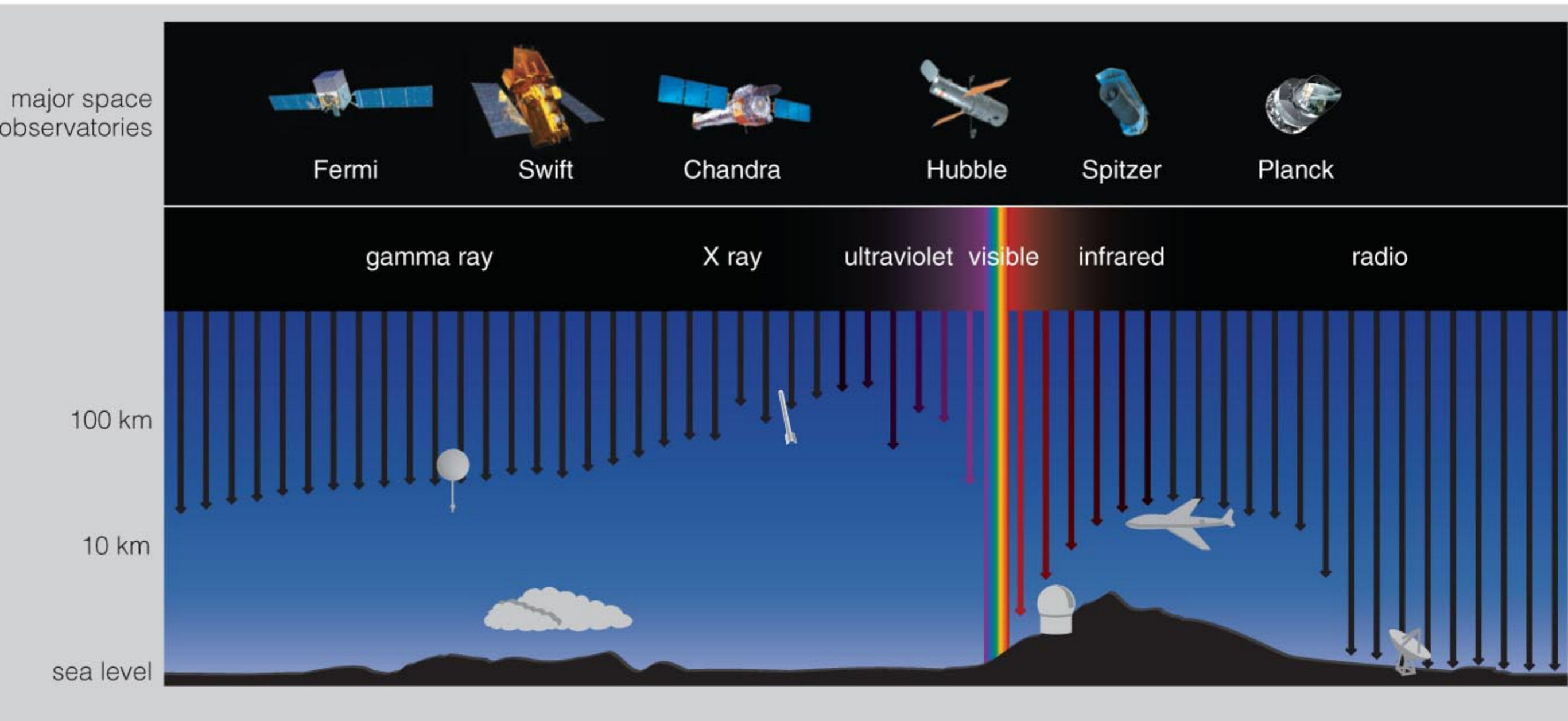
Georges Henri Joseph Édouard Lemaître in 1927 postulated the expansion of the universe based on Albert Einstein general relativity theory.



Electromagnetic spectrum

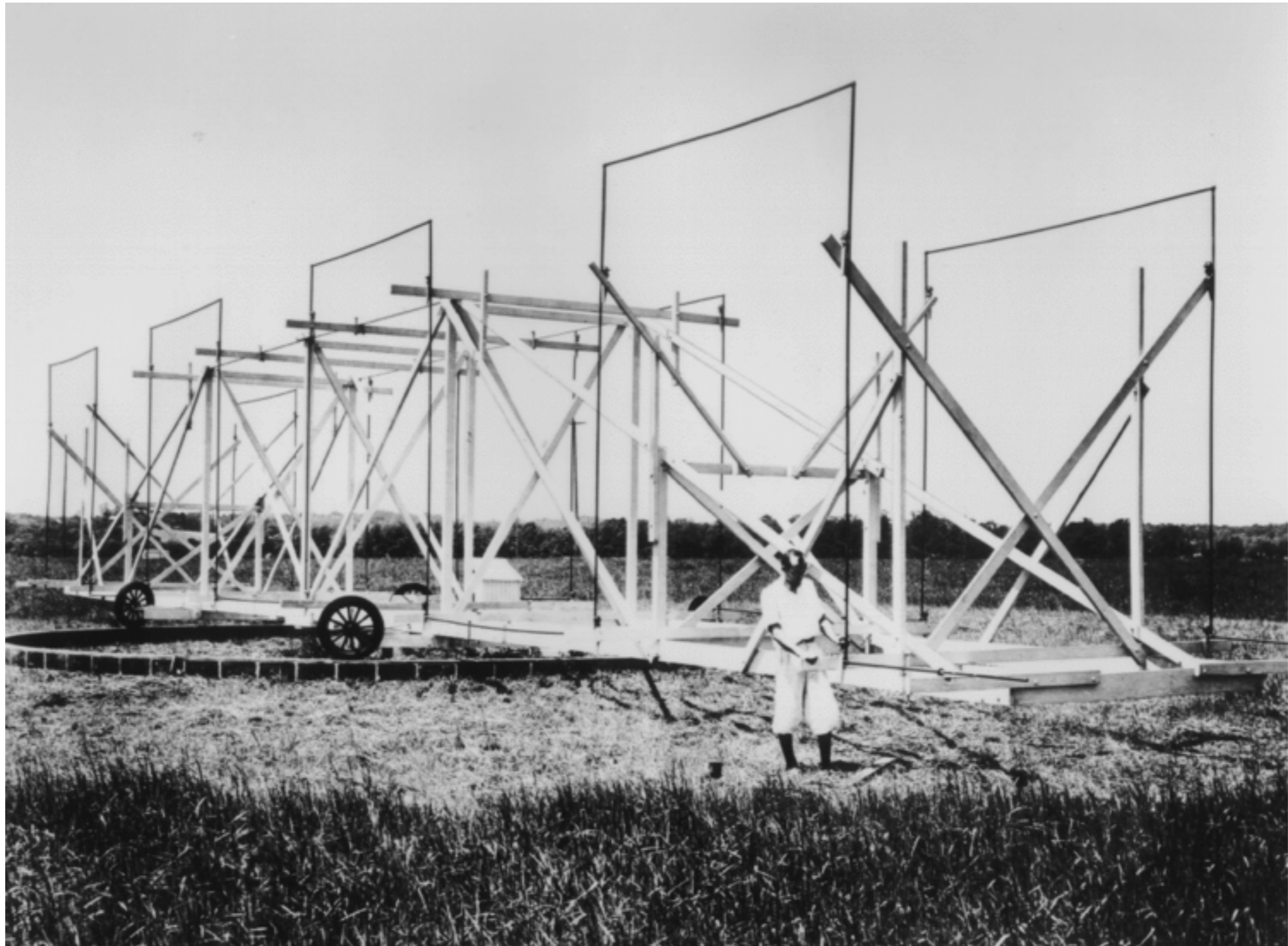


What we can see and what we cannot see from the ground



Dawn of radio astronomy

Karl Guthe Jansky, 1932



Karl Jansky's merry-go-round antenna (credit: AT&T/Bell Labs).

Dawn of radio astronomy

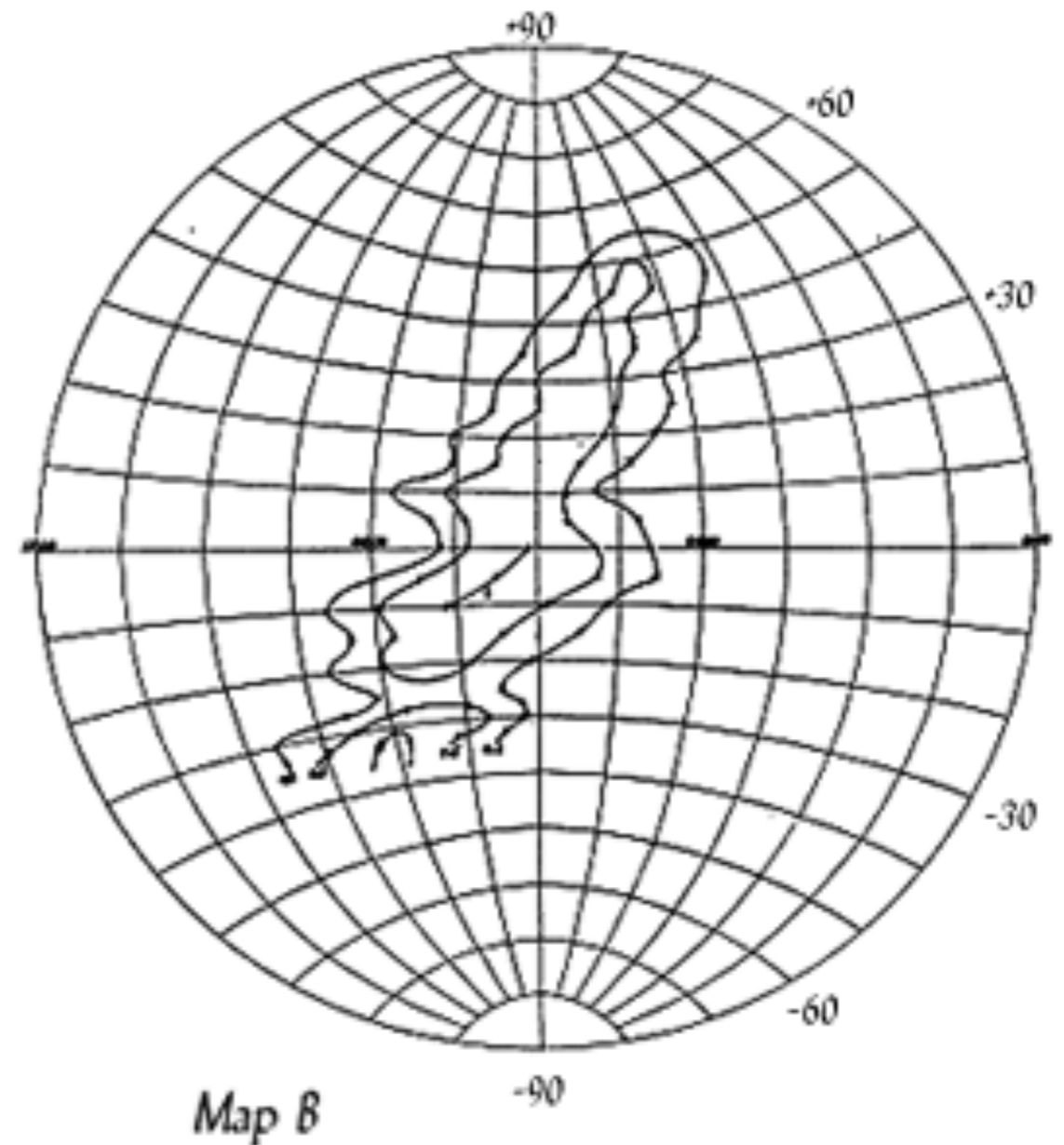
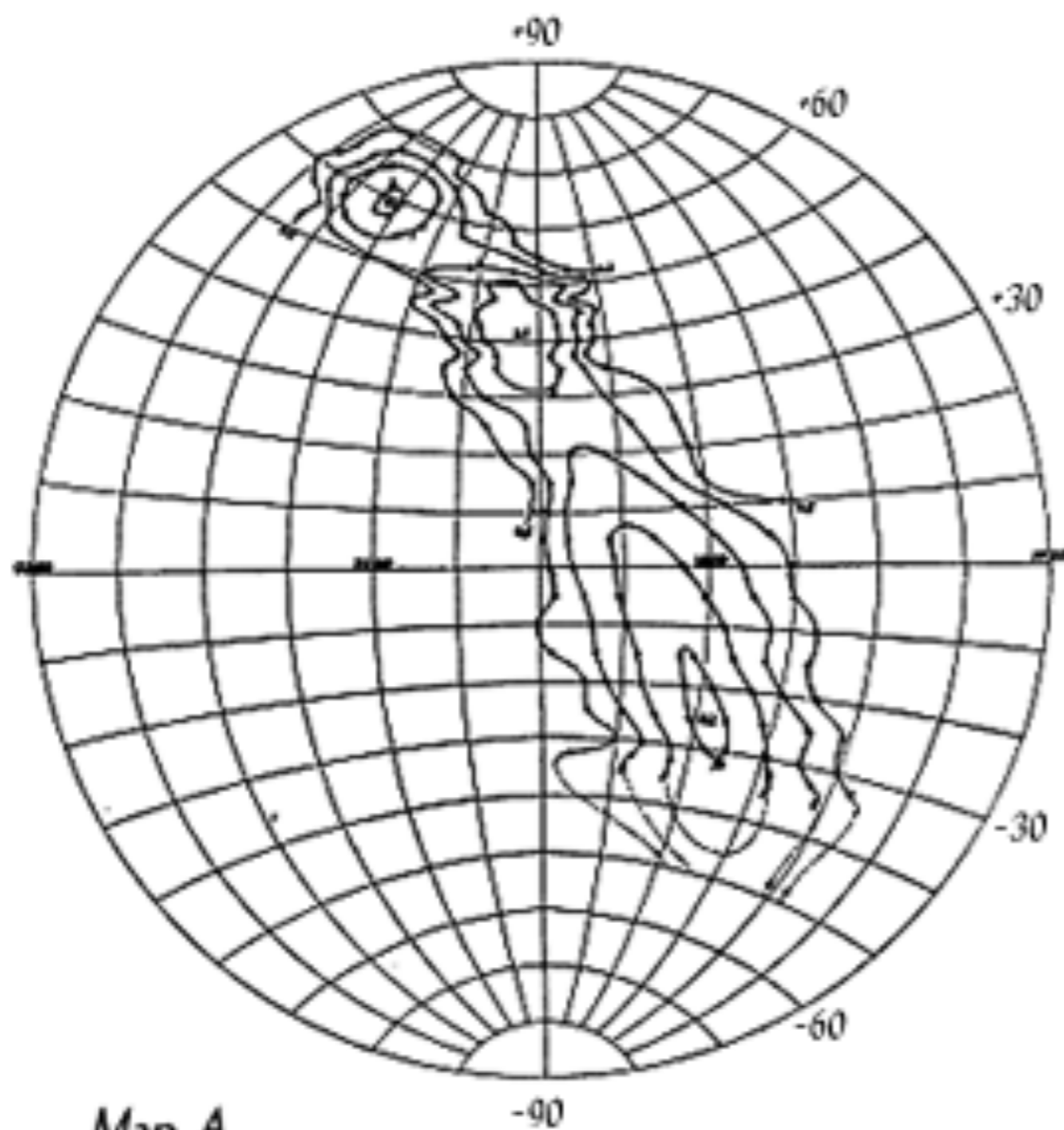
Grote Reber, 1938



The world's first radio telescope, built by the world's first radio astronomer Grote Reber in his backyard in Wheaton, IL. Credit: NRAO.

Dawn of radio astronomy

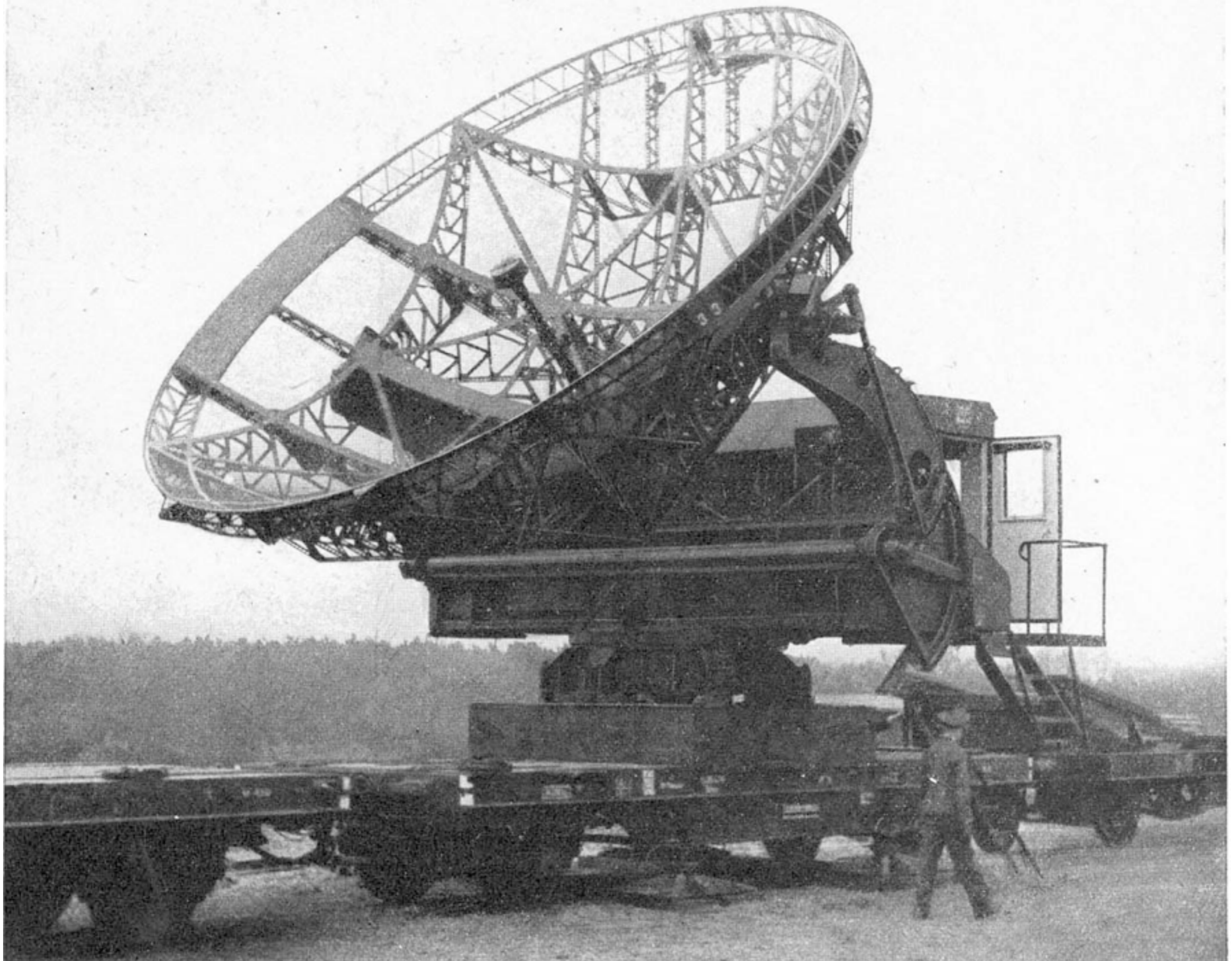
Grote Reber, 1938



Grote Reber's first all-sky map at radio wavelengths showing radio emission (160 MHz) in Sagittarius, Cygnus, Cassiopeia, and other constellations.

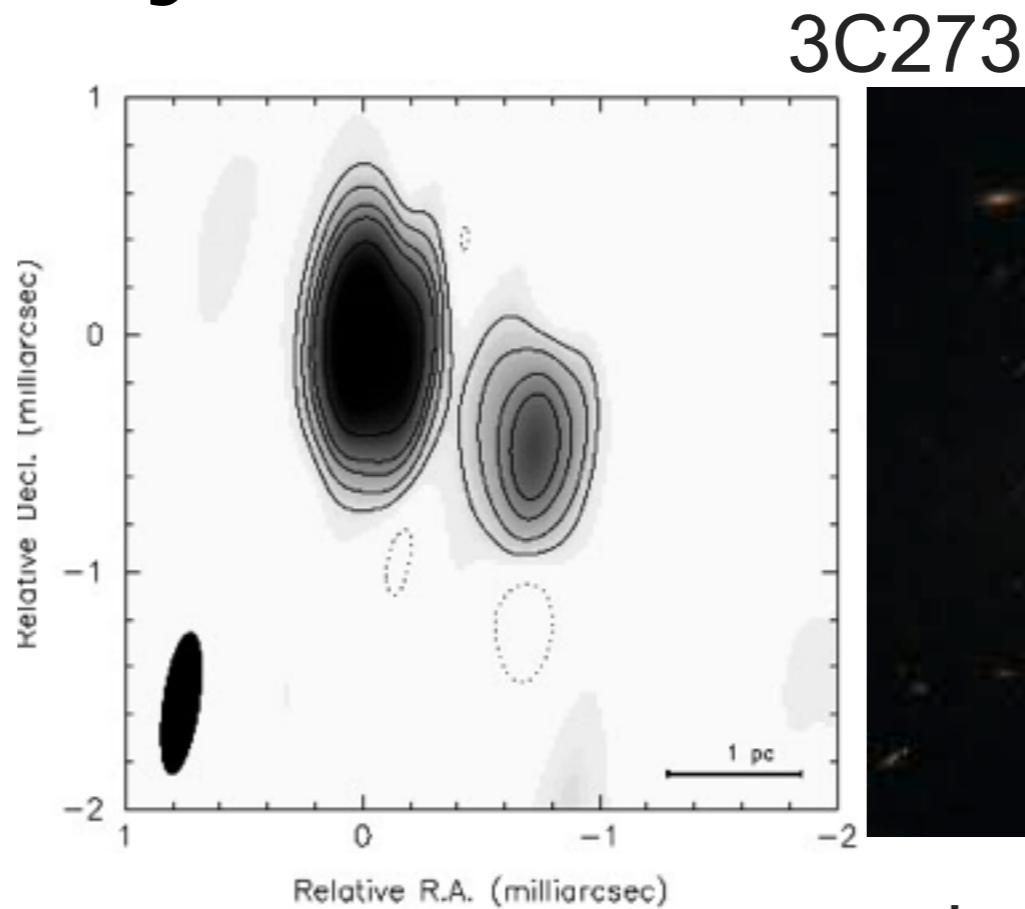
World War II: 1939 - 1945





Discovery of Quasars

Mullard Radio Astronomy Observatory (MRAO), near Cambridge.



in 1963, Maarten Schmidt (Caltech), discovered that 3c 273 was 1 billions light years away!

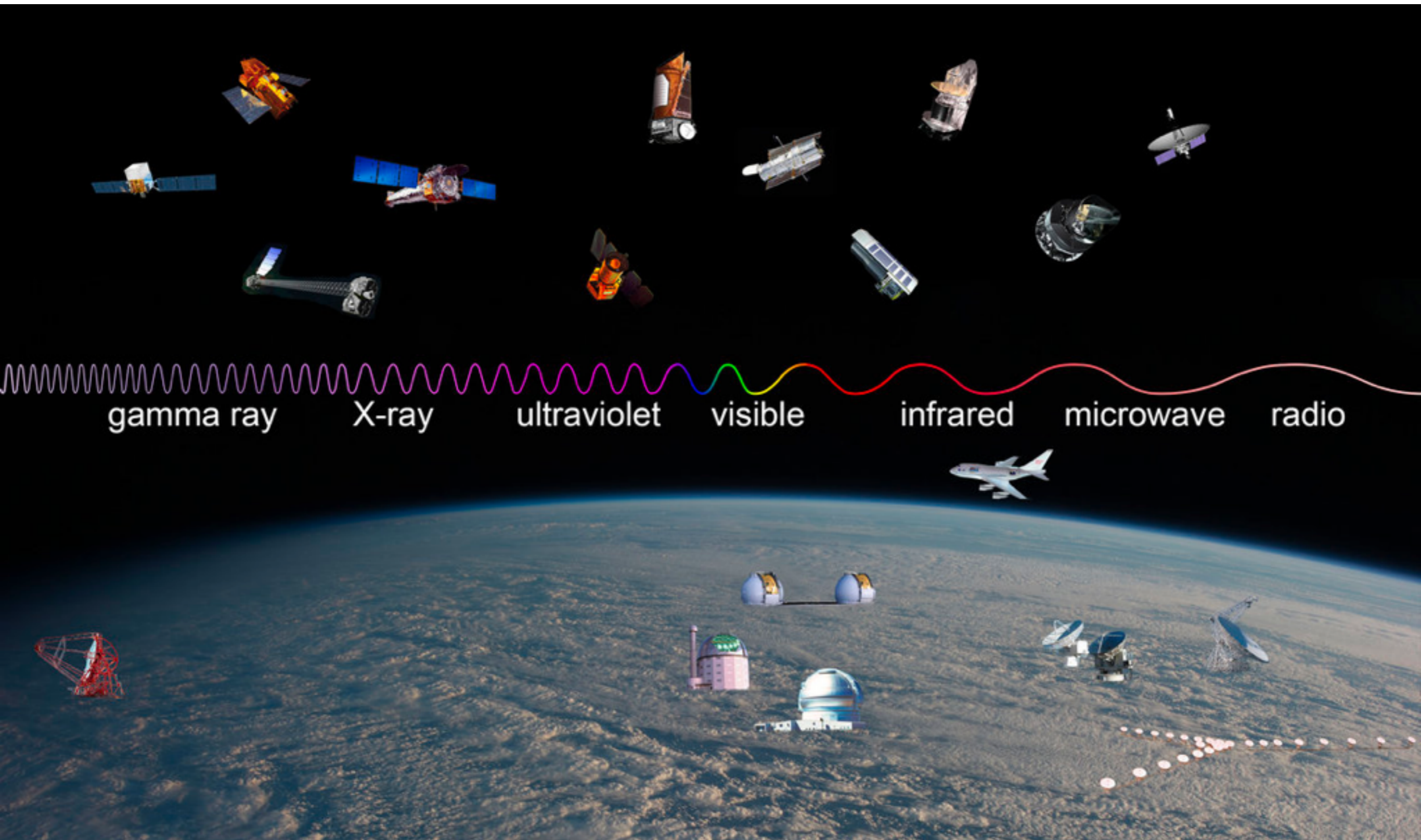
3C273 was the most distant object ever observed

Super massive black holes and the violent Universe

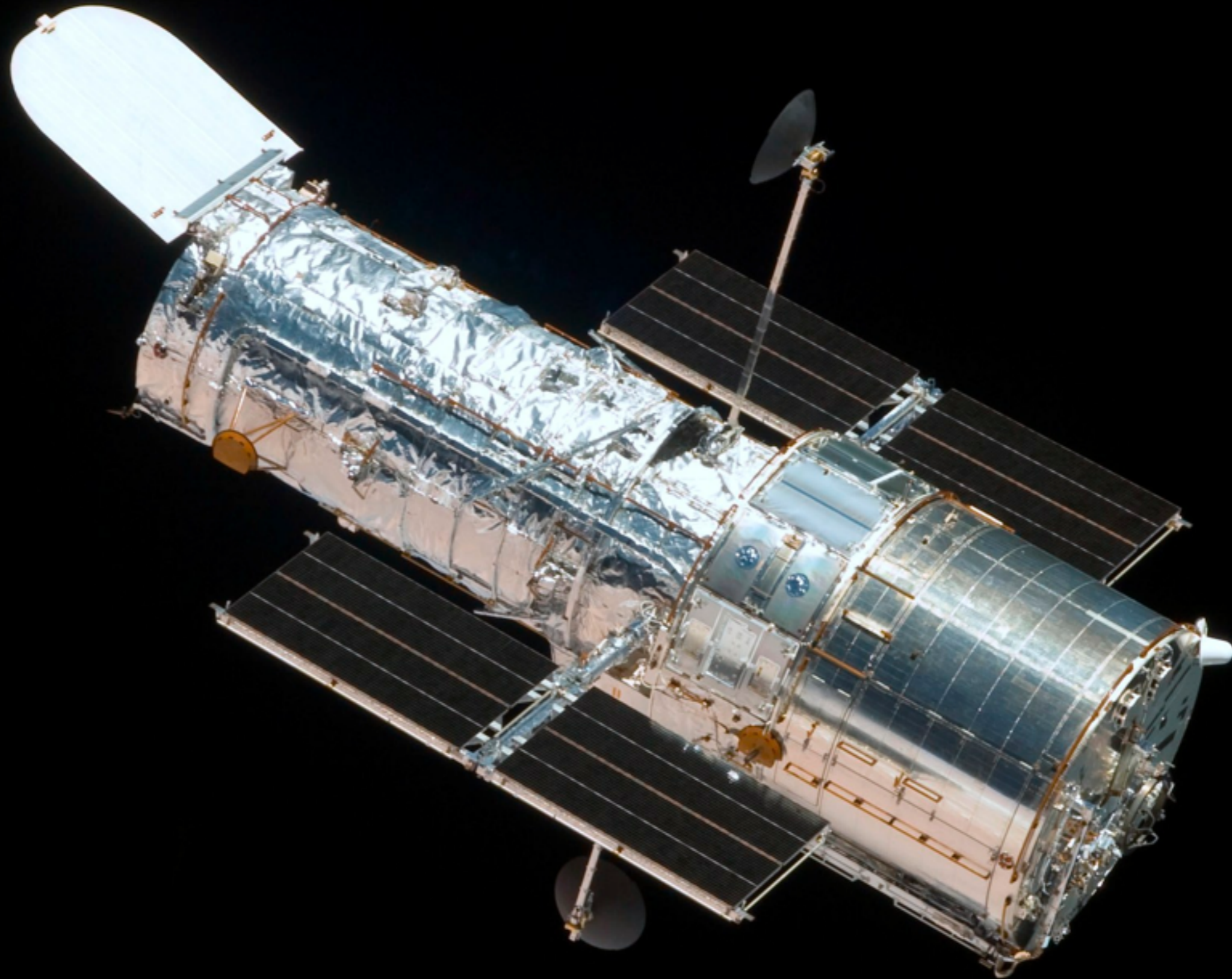
3C273



The dawn space exploration and giant telescope



Hubble Space Telescope (1990-)



The Orion Nebula

Henry Draper, 1880





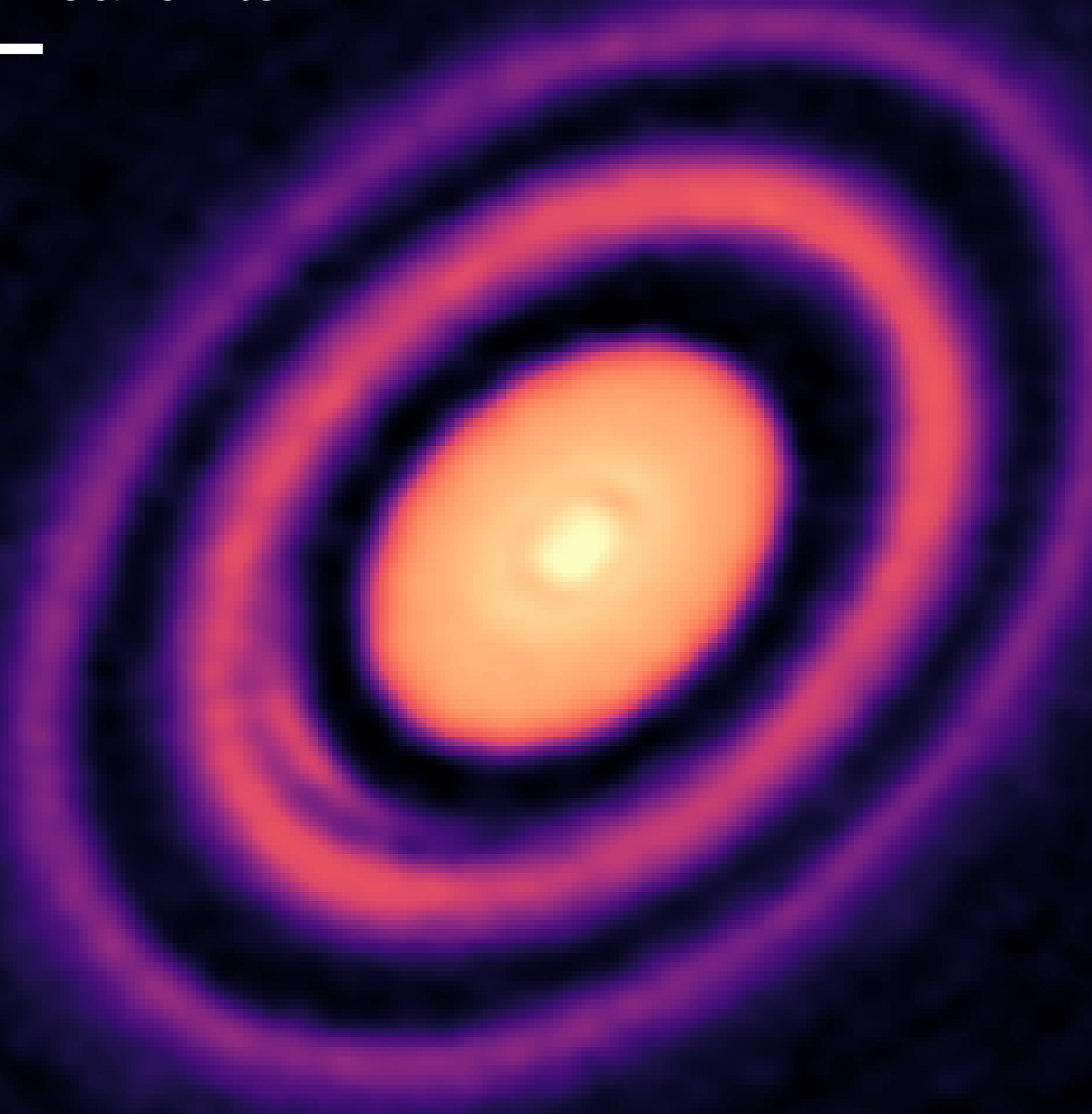


Atacama Large Millimeter Array (ALMA)





10 astronomical units

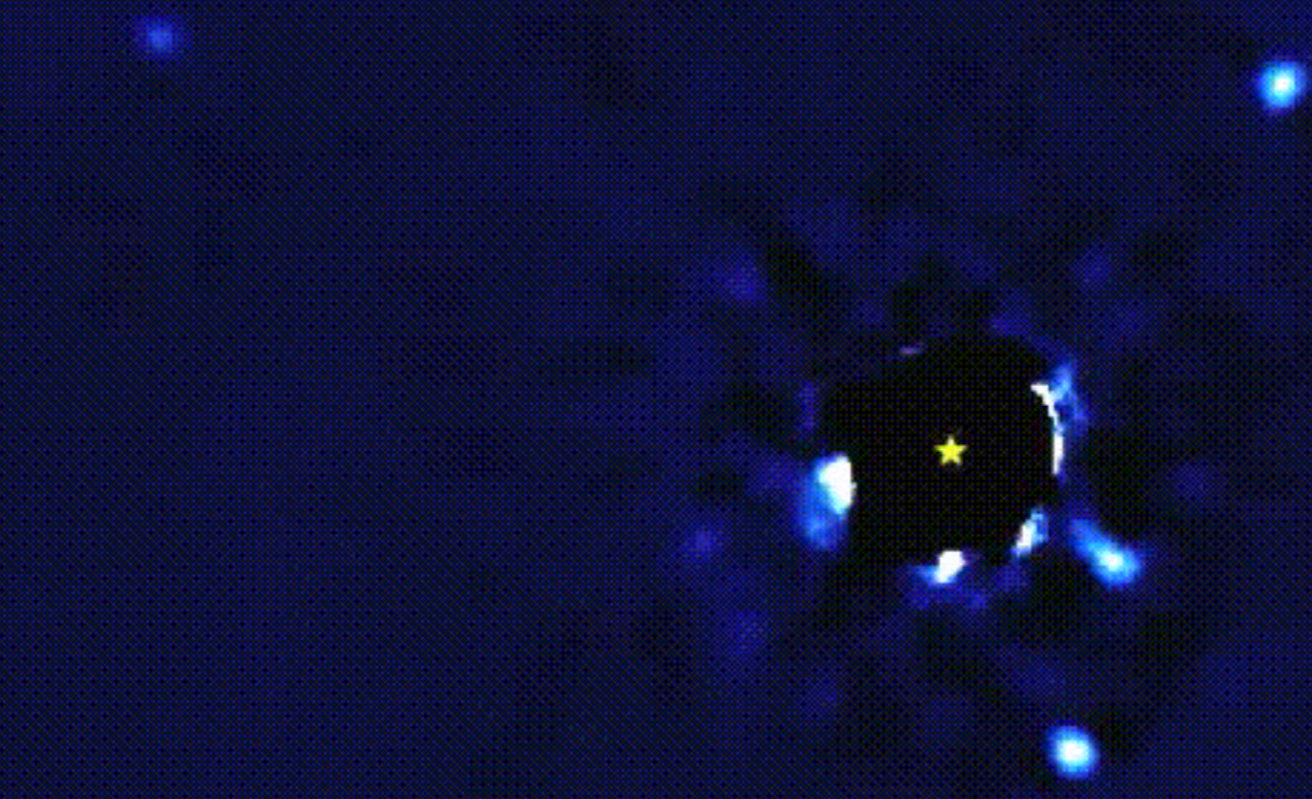


HD 163296, 330 light years away

The Keck Telescopes



HR 8799, 130 light years away



2009-07-31

20 au

https://exoplanets.nasa.gov/

EXOPLANET EXPLORATION
Planets Beyond Our Solar System

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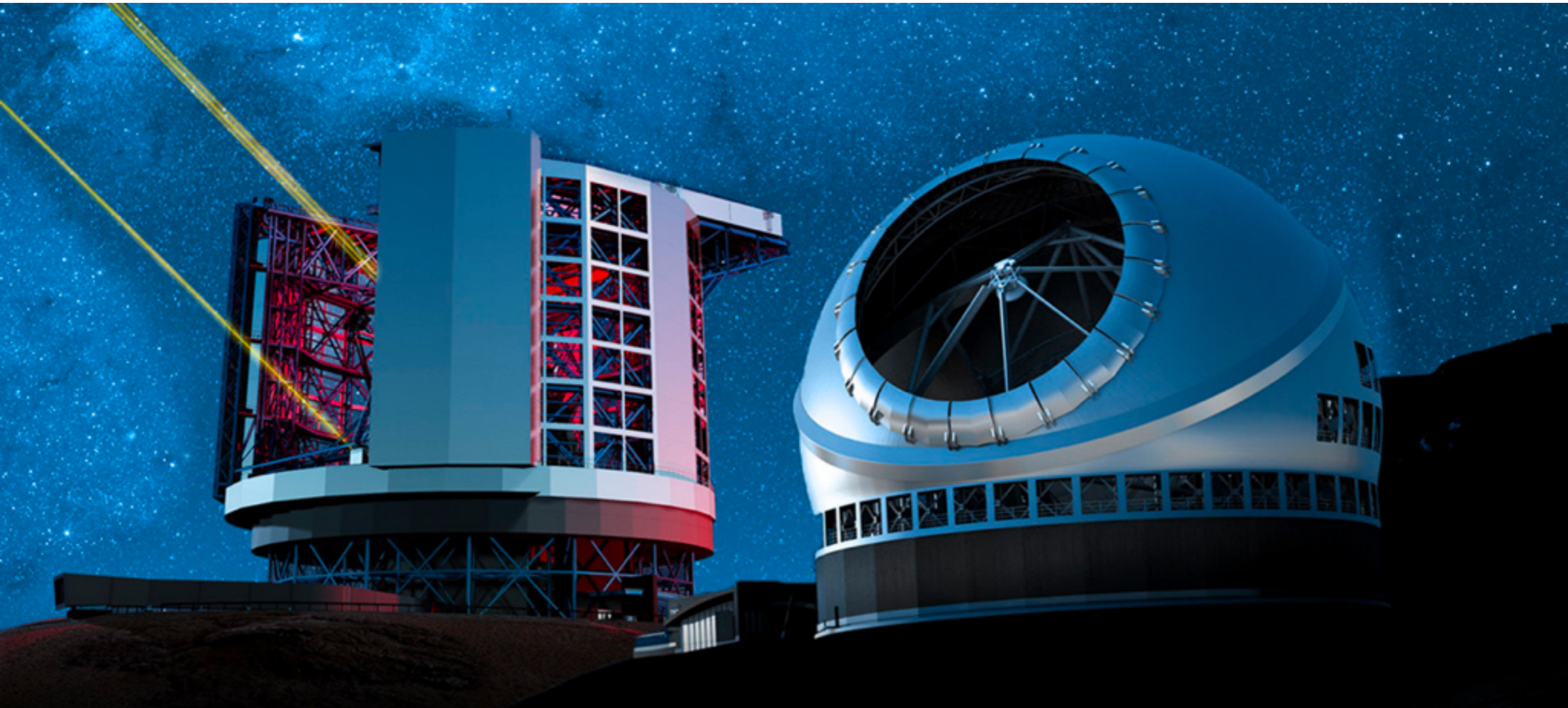
Exoplanets Last update: October 4, 2018	3,791 CONFIRMED	2,919 NASA CANDIDATES	2,828 PLANETARY SYSTEMS	Glossary › FAQ ›
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Future space telescopes



Launch scheduled for March 30, 2021

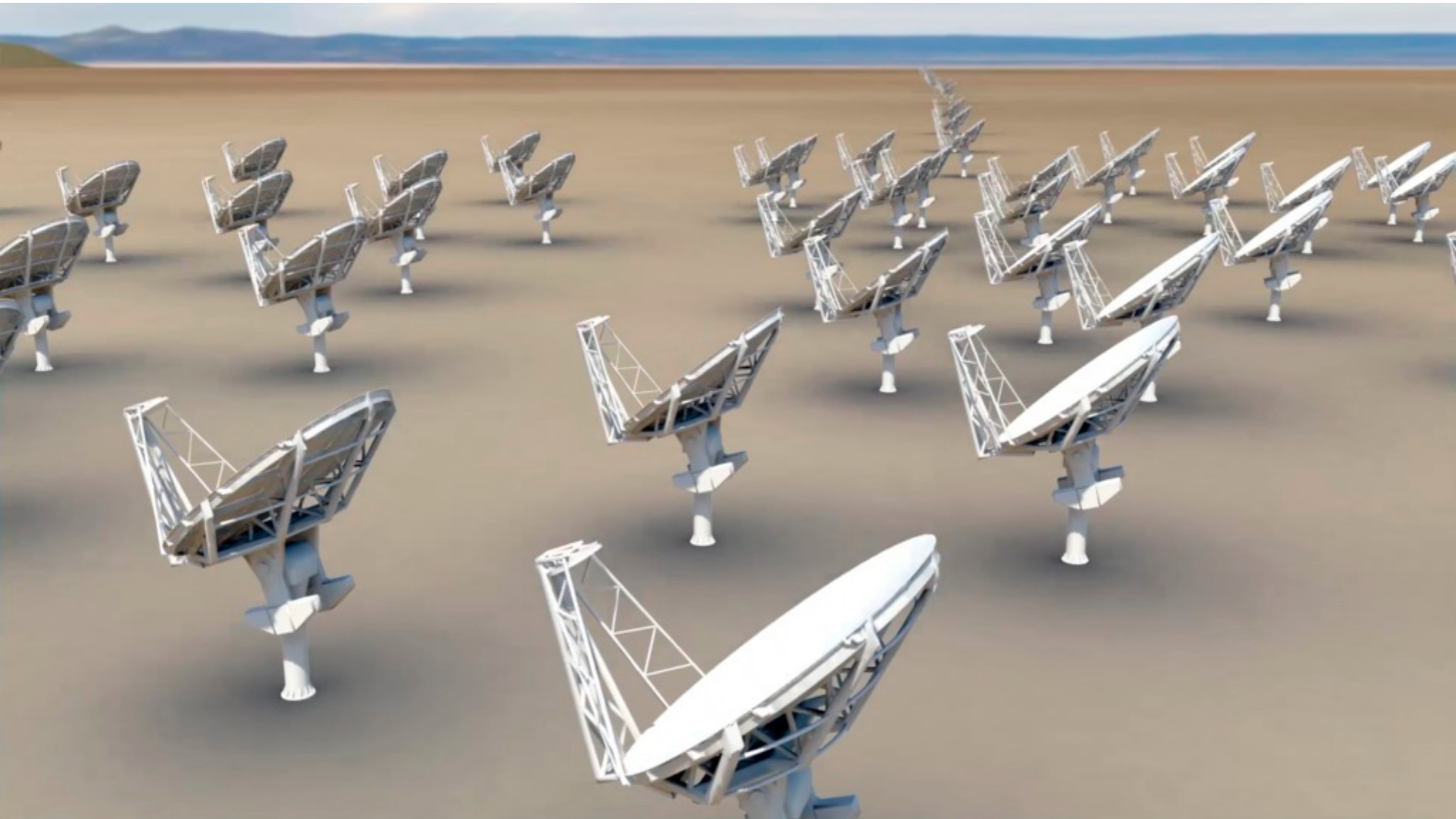
Future telescopes on the ground



Will start operation between 2025-2030

Next Generation Very Large Array (including Texas)

<http://ngvla.nrao.edu/>



2030 and beyond

Thank you for attending the
Rice Observatory Open House!