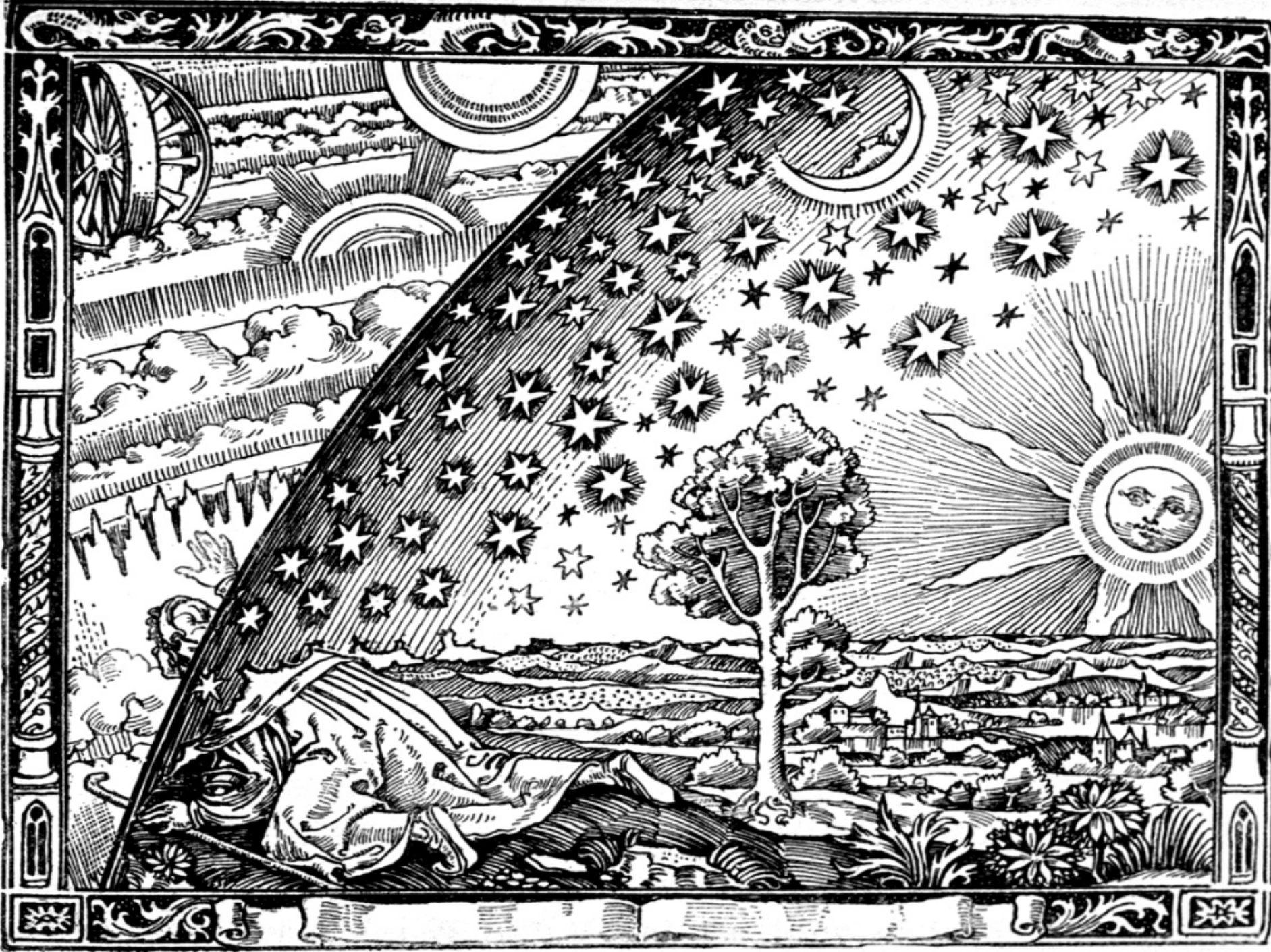


Exploring the Universe





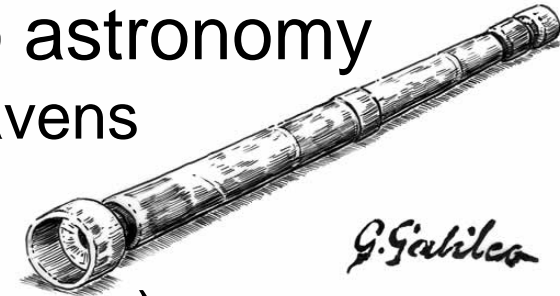
Scientific Revolution

- Nicolaus Copernicus
 - Planets orbit the Sun
- Giordano Bruno
 - Stars are suns, with their own planets
 - These could harbour life
- Galileo Galilei
 - Confirmed Copernicus' view: Earth is not the center of the Universe



Galileo Galilei

- Applied decisive new technology to astronomy
 - First to use telescope to study the heavens
- This provided
 - Increased *sensitivity* (light-collecting power)
 - Increased *resolution* (image sharpness)
- Led to remarkable discoveries
 - The Moon has mountains
 - Jupiter has its own moons
 - Venus has phases, like the Moon
 - The Milky Way consists of individual stars

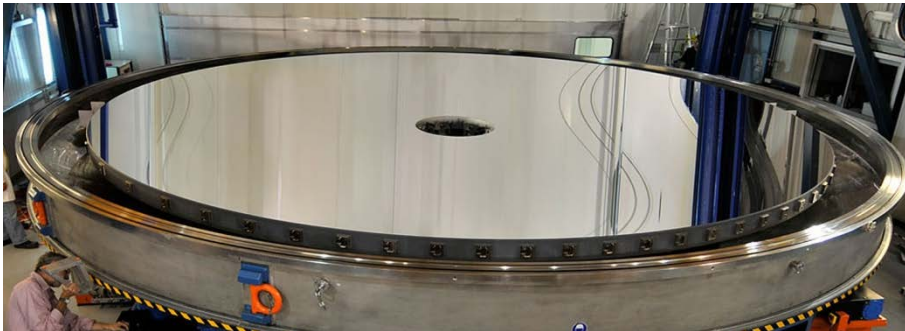


Observations January 1610

2. J. stars mag. H. 12	○ * *
30. moon	* * ○ *
2. J. stars	○ * * *
3. moon	○ * *
3. Ho. J.	* ○ *
7. moon	* ○ * *
6. moon	* * ○ *
8. moon H. 17.	* * * ○
10. moon	* * * ○ *
11.	* * ○ *
12. H. q. way	* ○ *
17. moon	* * ○ *
14. stars	* * * ○ *

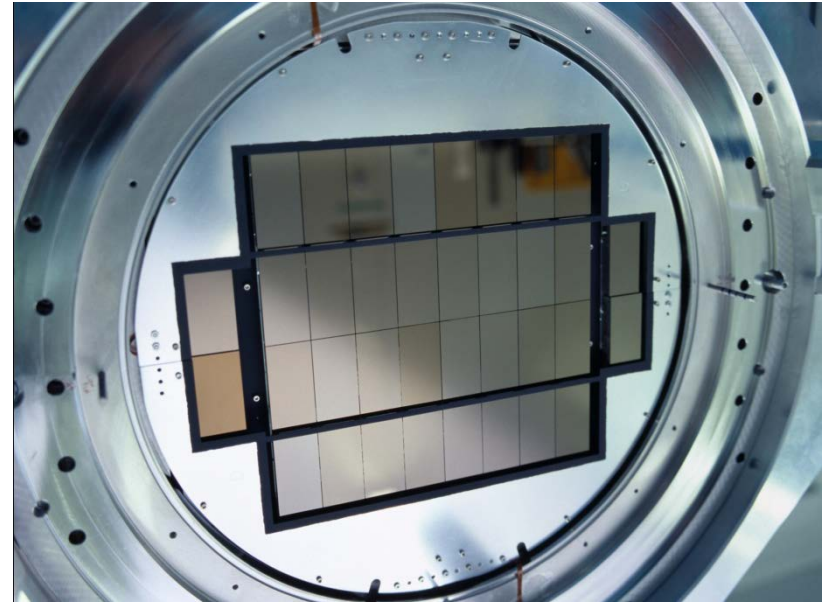
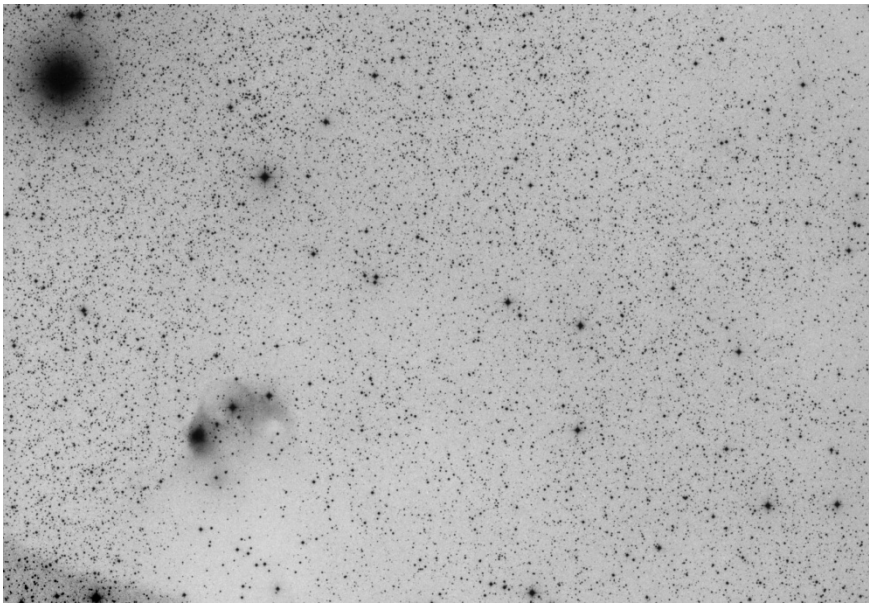
Better Telescopes

- Refractors using lenses \Rightarrow reflectors using mirrors
- Larger mirrors: better sensitivity and resolution



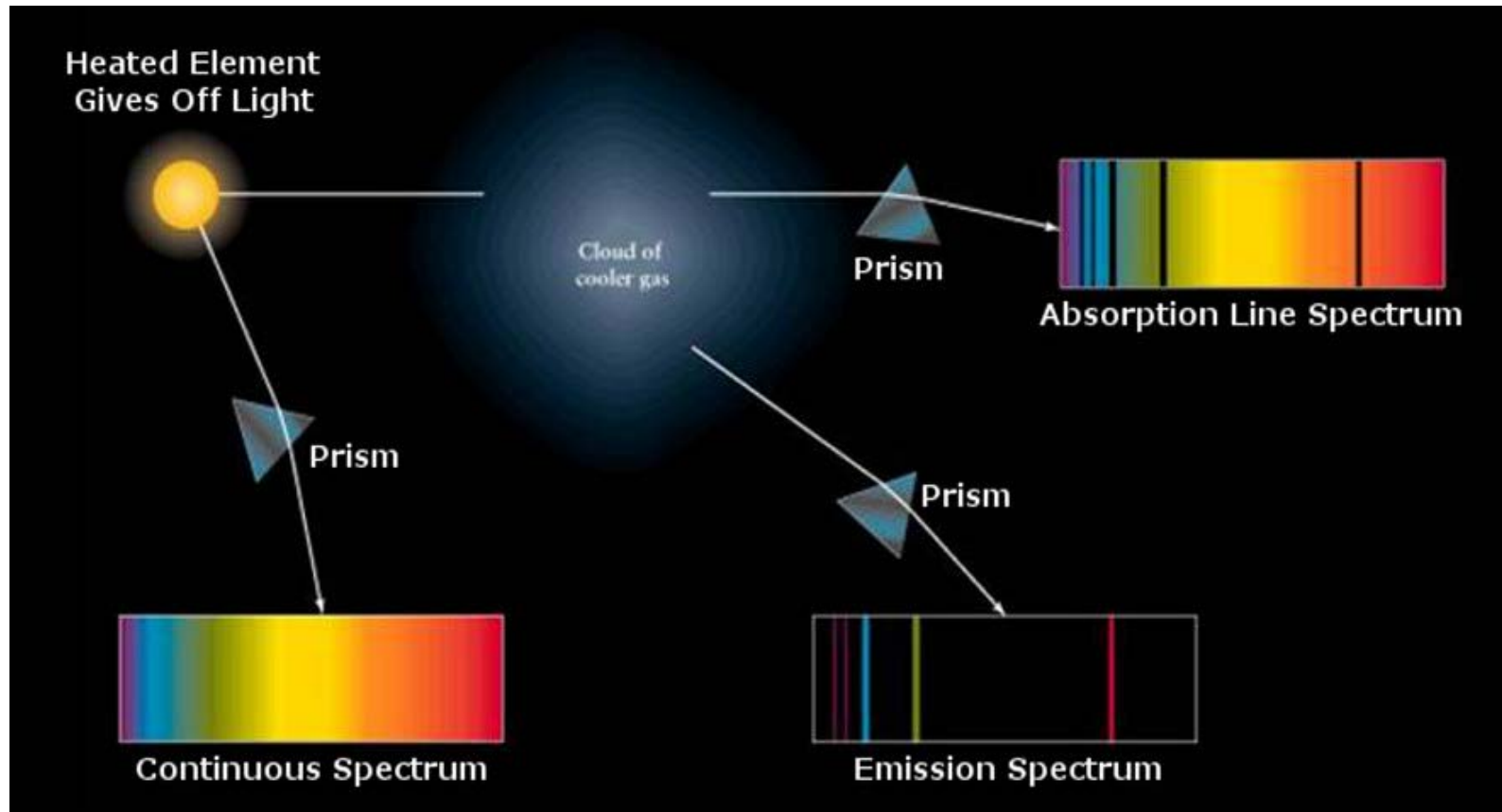
Better Detectors

- Eye \Rightarrow photographic plate: long exposures possible
- Now replaced by very sensitive electronic detectors



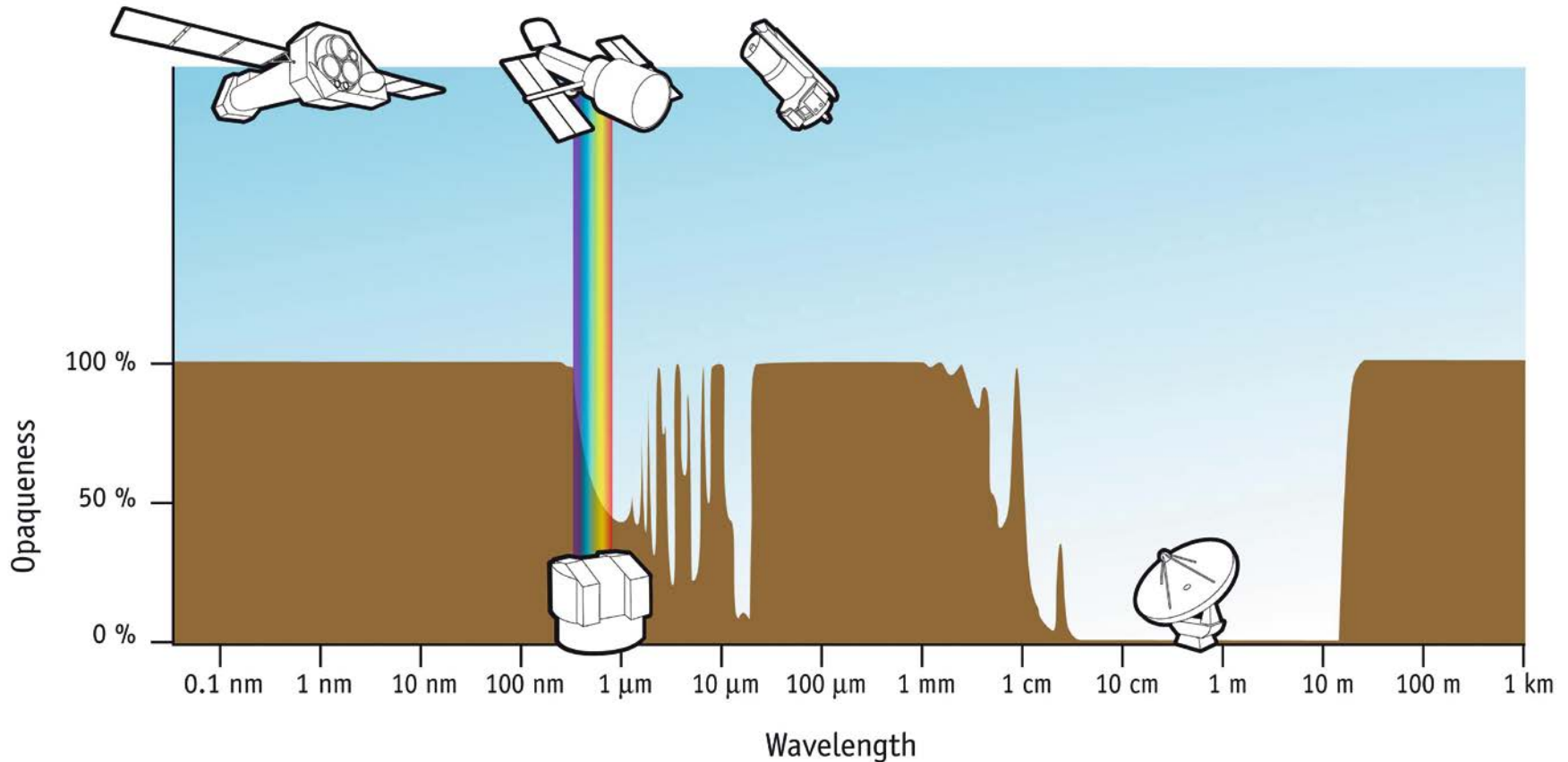
Spectroscopy

- Disperse light into colours of the rainbow
 - Originally for point source, now also over an area
- Allows to deduce physical properties of objects



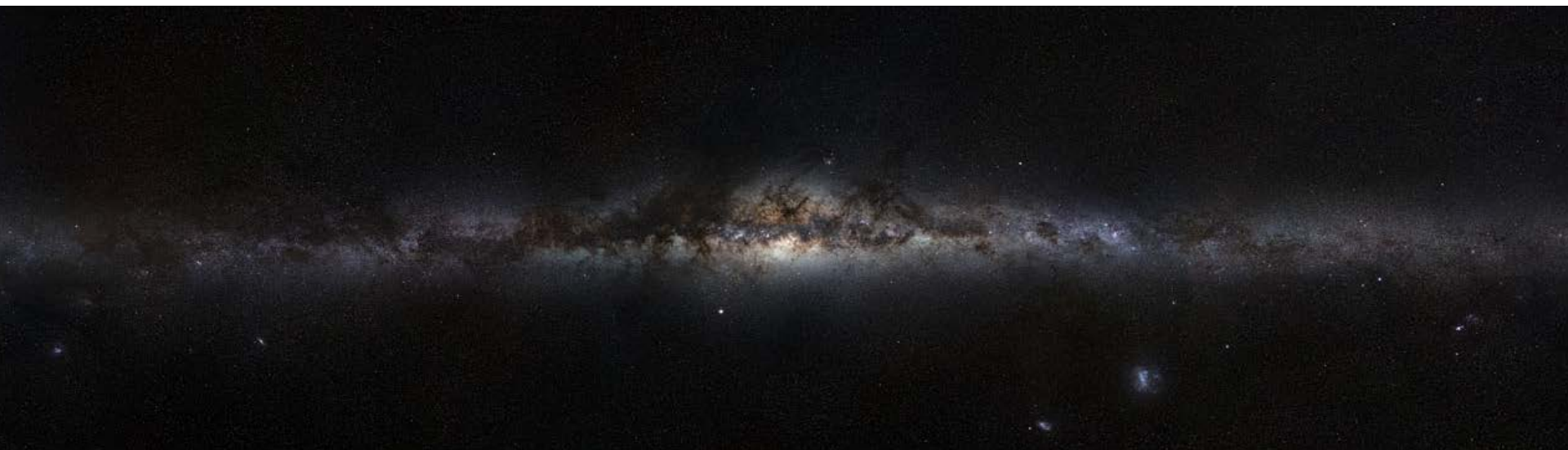
Other Wavelengths

- Visual and radio waves observable from the ground
- Other wavelengths require space telescopes

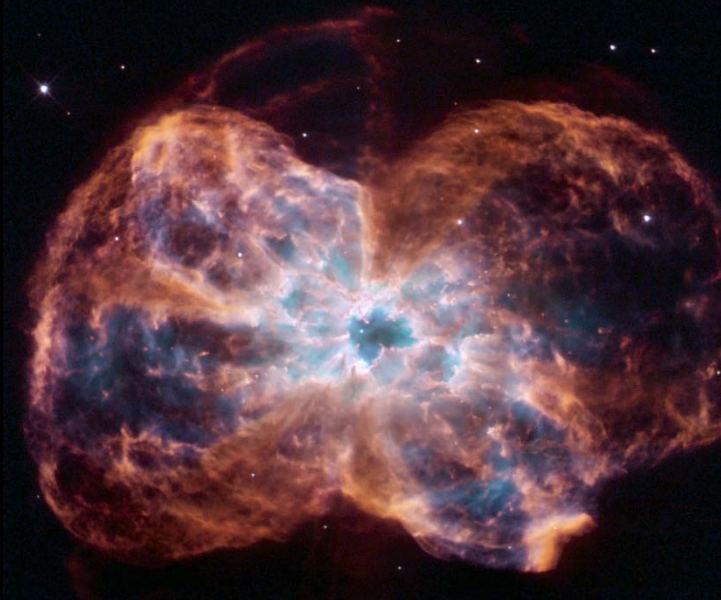
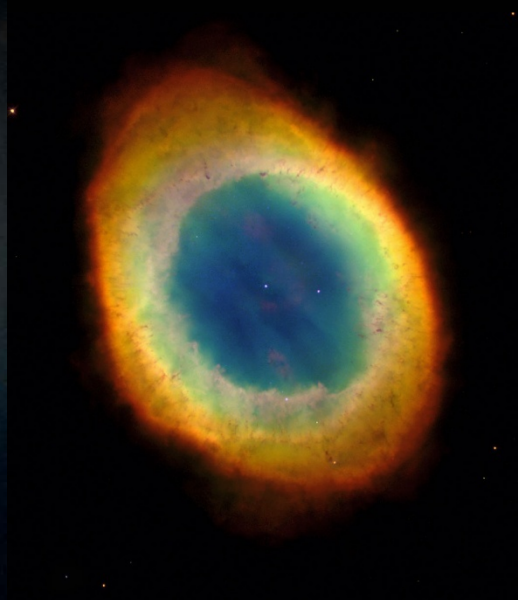
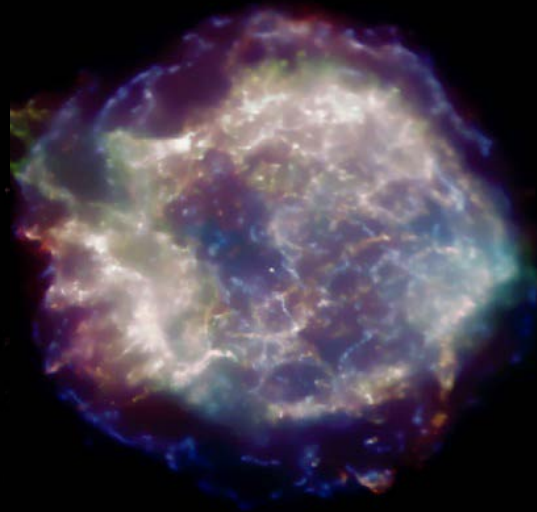
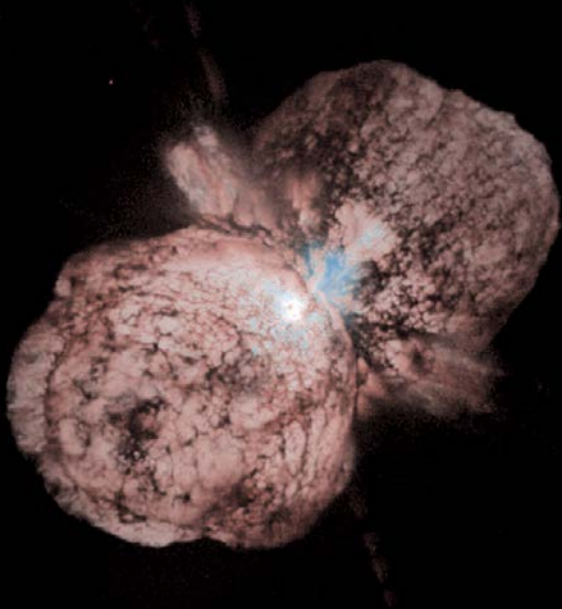


A strange and wondrous Universe

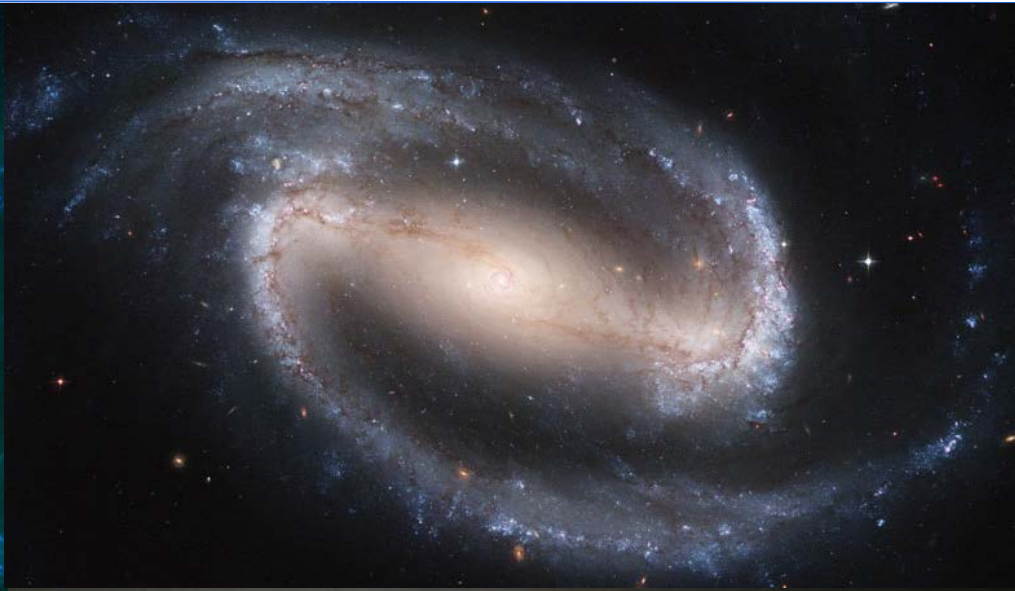
- Increasingly powerful telescopes revealed
 - Stars, planets and comets, and but also fuzzy nebulae
 - Some are gas clouds in the Milky Way
 - Most are in fact entire galaxies at large distances
- Led to the realization
 - Milky Way is a spiral galaxy, with Sun orbiting its centre
 - The Universe is very very very large, and full of galaxies



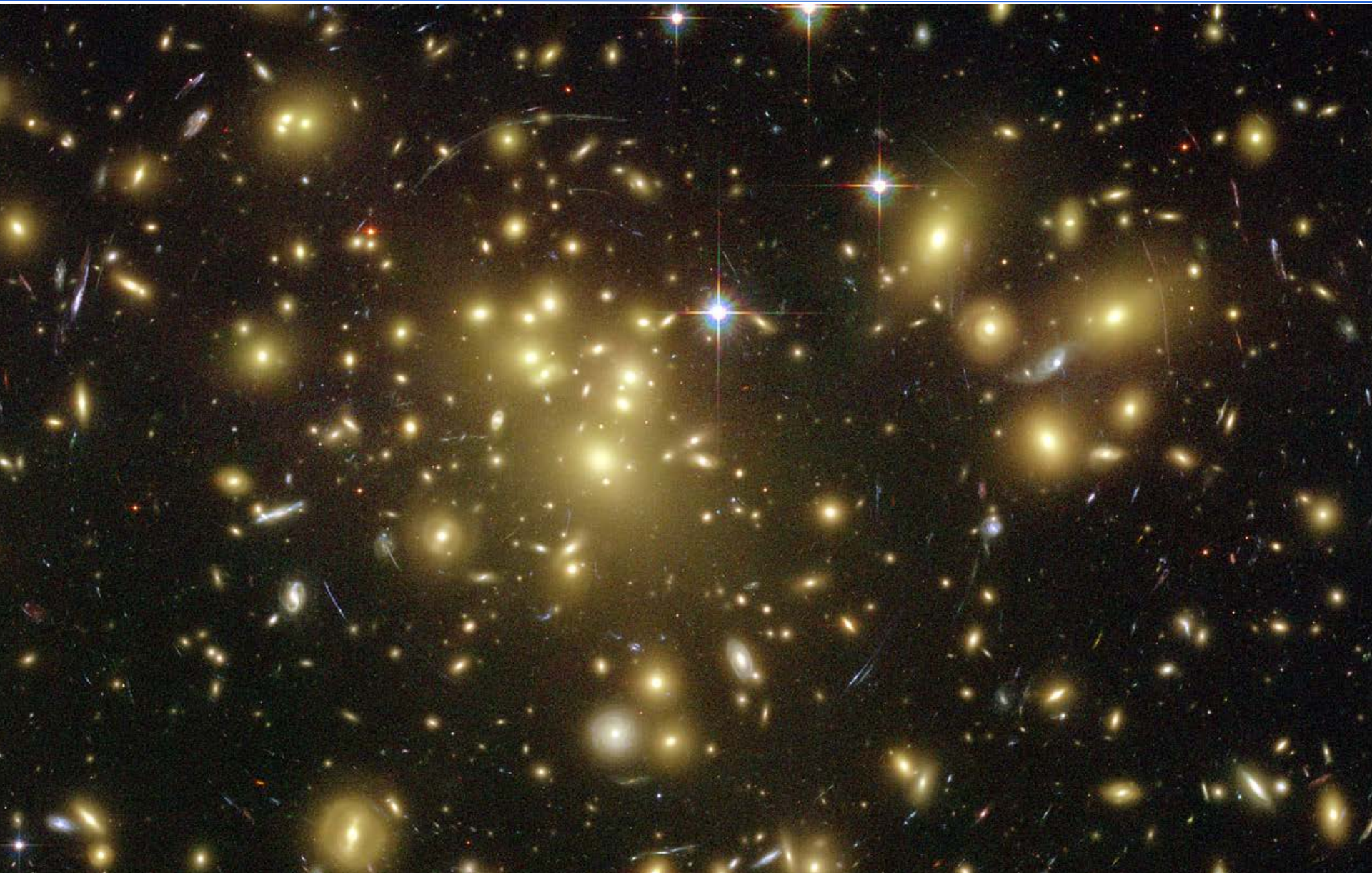
Dying Stars



Galaxies



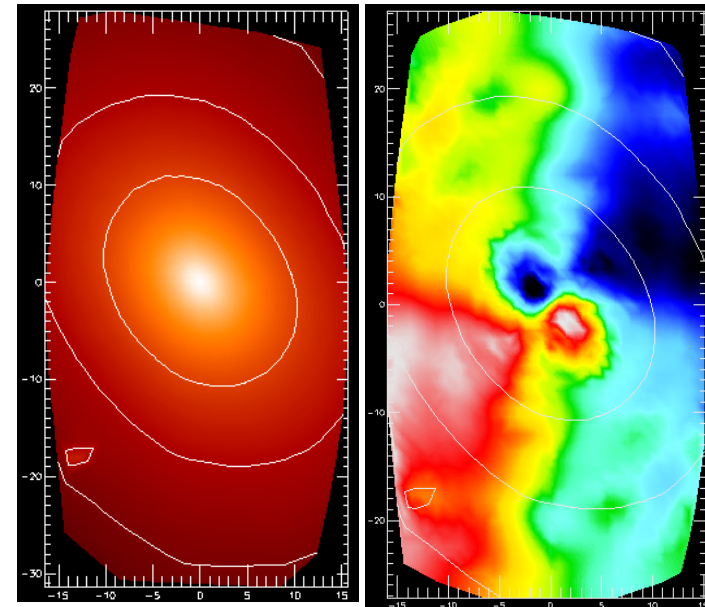
Cluster of Galaxies





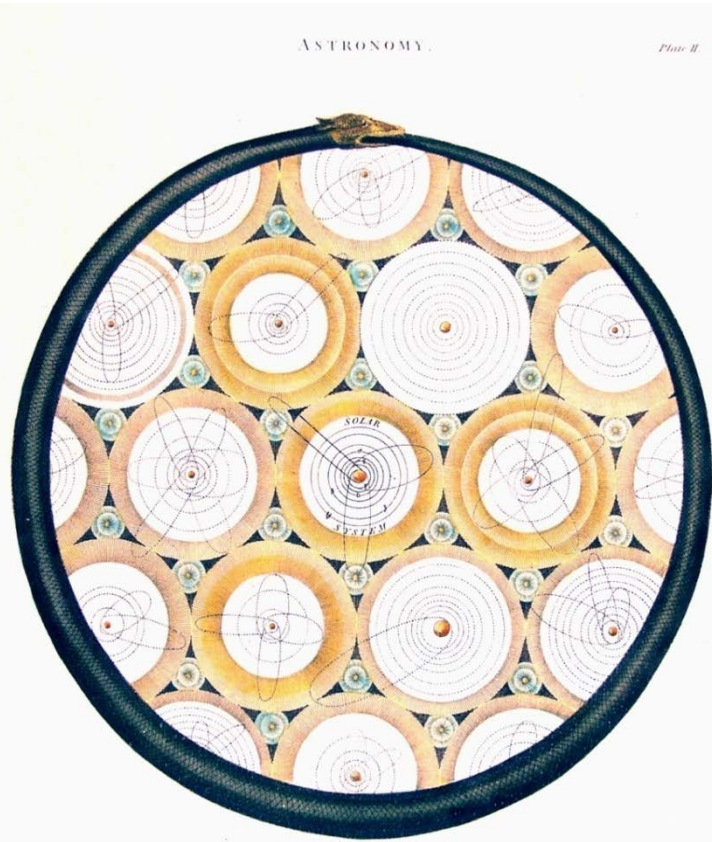
Today's Telescopes

- See objects all the way back in time: early Universe
 - Far away = Long ago
 - Night sky is a giant history book
- Enable detailed studies of galaxies & the Milky Way



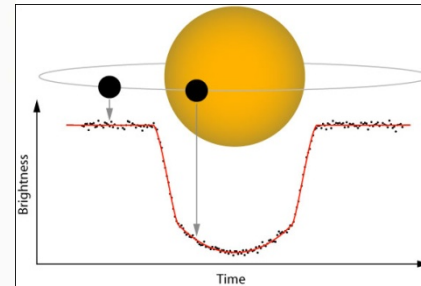
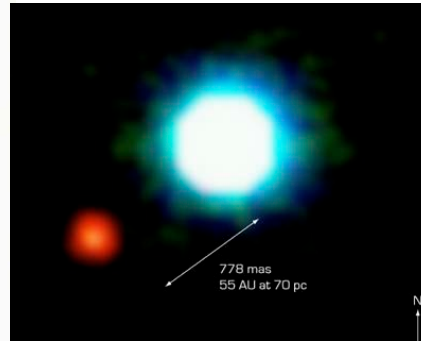
Planets orbiting other stars

- Distances to even the nearest stars are immense
 - Only recently possible to detect exo-planets
 - Direct imaging, transits, reflex motion of parent star

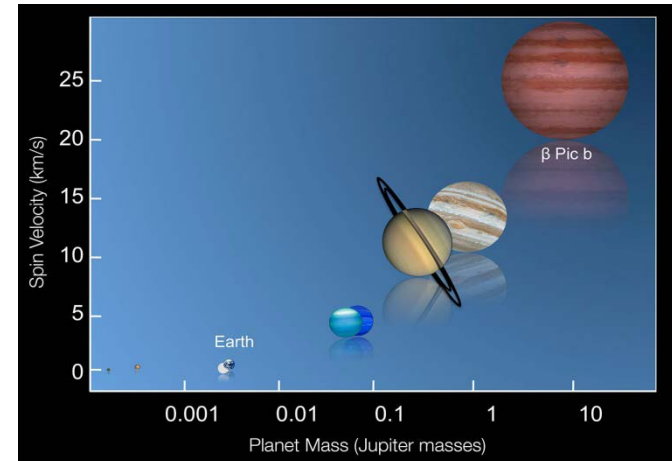
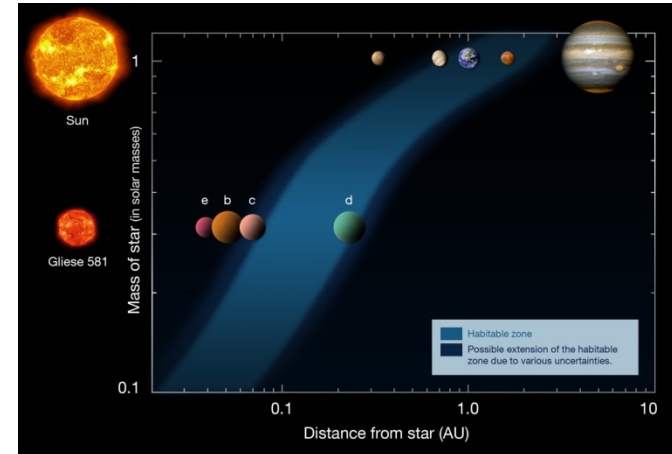


1798

Universal Solar System.



15

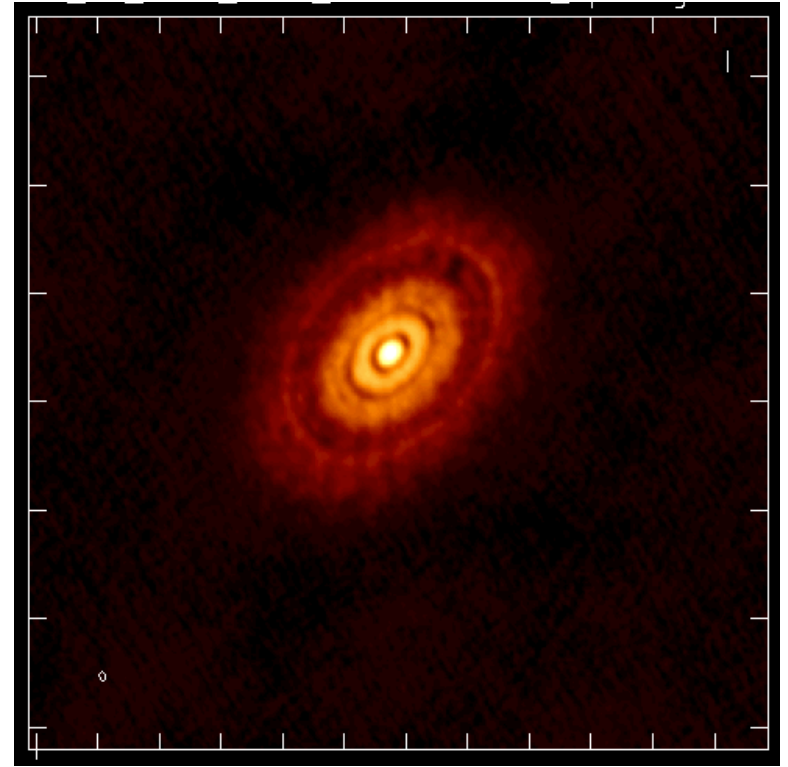
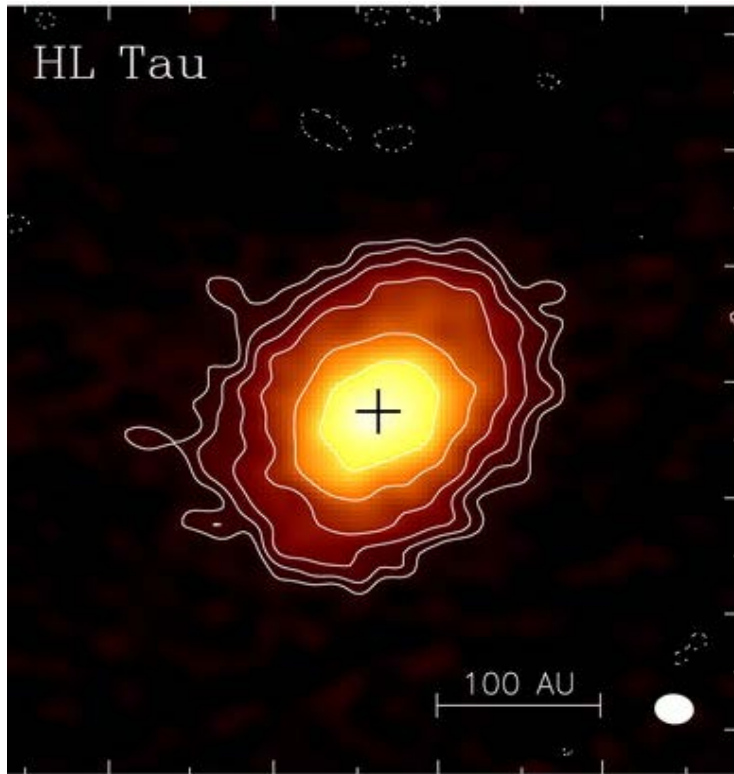


Theory and Observations

If simple perfect laws uniquely rule the Universe, should not pure thought be capable of uncovering this perfect set of laws without having to lean on the crutches of tediously assembled observations? True, the laws to be discovered may be perfect, but the human brain is not. Left on its own, it is prone to stray, as many past examples sadly prove. In fact, we have missed few chances to err until new data freshly gleaned from nature set us right again for the next steps. Thus pillars rather than crutches are the observations on which we base our theories; and [...] these pillars must be there before we can get far in the right track.

Martin Schwarzschild 1957

Planet-forming disc with ALMA



The Future

- New tremendous capabilities
 - ALMA with 66 antennas has come on line
 - James Webb 6.5m Space Telescope launch in 2018
 - ESO's 39m Extremely Large Telescope ready in 2024
- Provide a technological jump as large as Galileo's!

