Science 2 – new for 2024/2025!

Is there a **Scientific Method** after all?

Scientists rarely follow *one straightforward path* to understanding the natural world…

In the modern times, we speak of "**practices of science**" —
or the many ways in which scientists look for answers.

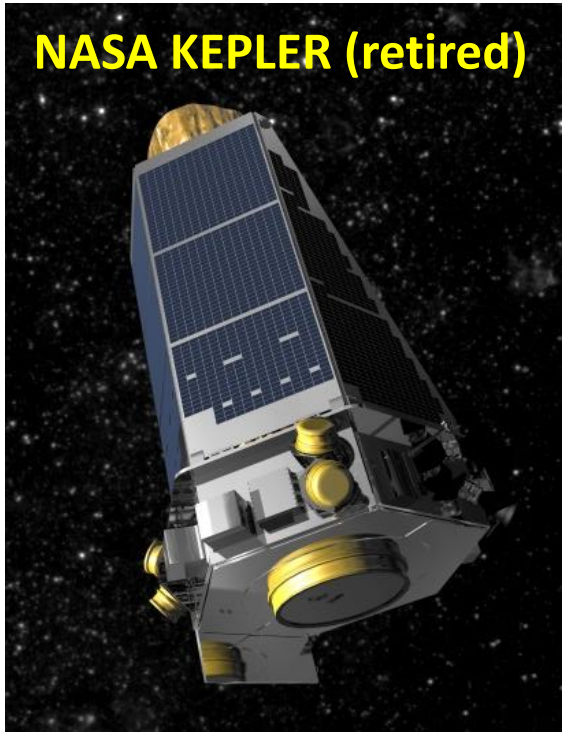
OBSERVATION **EXPERIMENTATION**

ANALYSIS **MODELLING**

CLASSIFICATION **SYNTHESIS**

How to study Cosmos?

Just about everything we know about the Universe comes from the study of light emitted or reflected by objects in space.

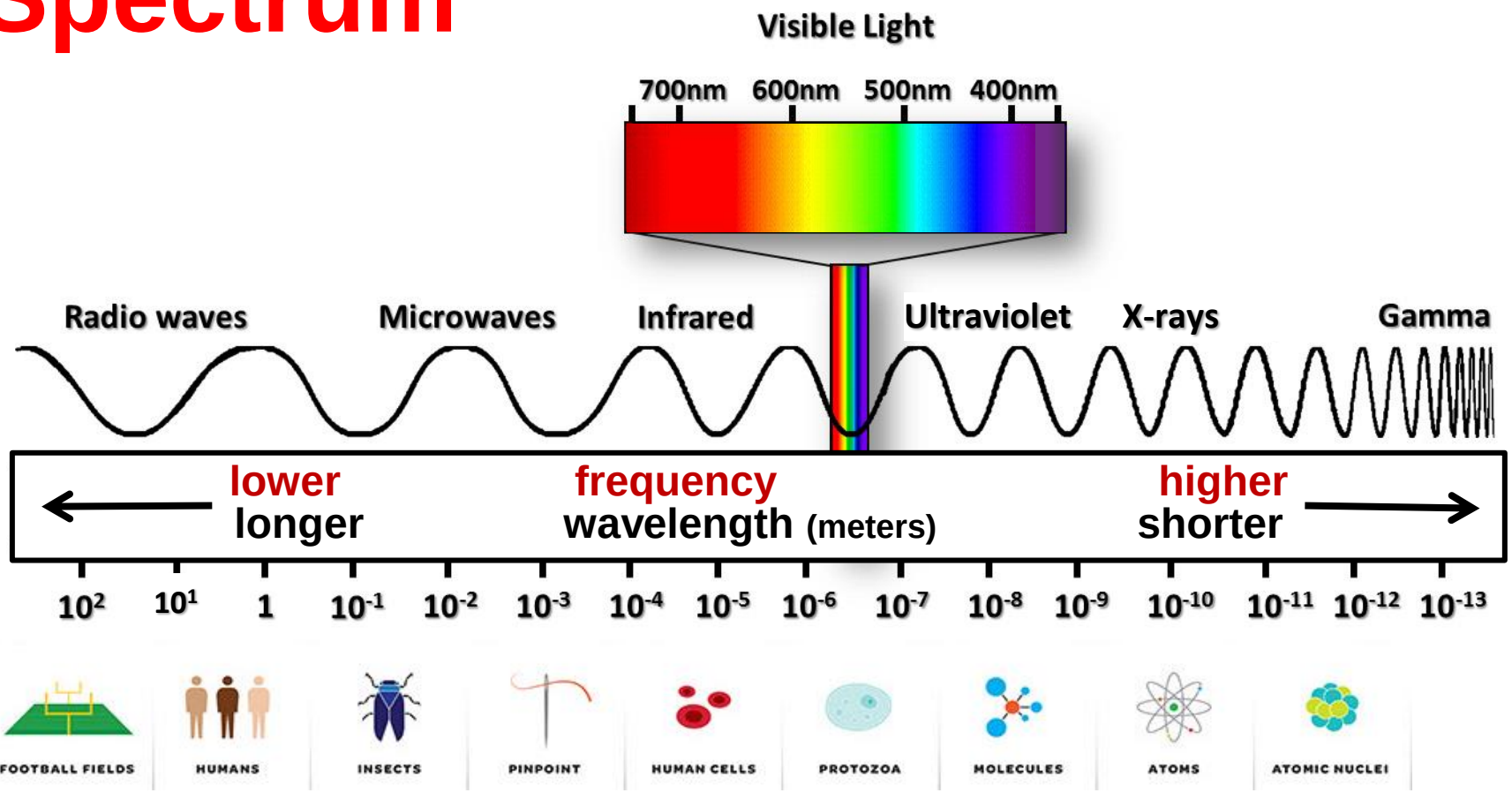


- **Telescopes** are used to gather light from distant objects and let us see them "up close". Astronomers use many different types of telescopes some of which are located right here on Earth and some are sent into space.

- **Spectrographs** break the light up into a *spectrum* ("color" composition) which tells us the temperature, chemical composition and velocity of stars, planets, galaxies and nebulae.

Electromagnetic Spectrum

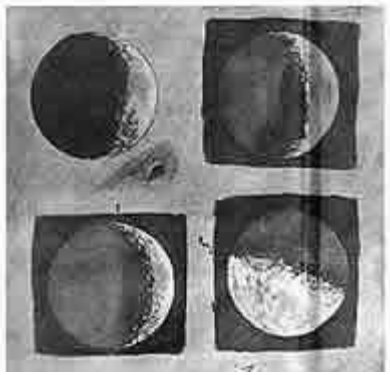
REVIEW



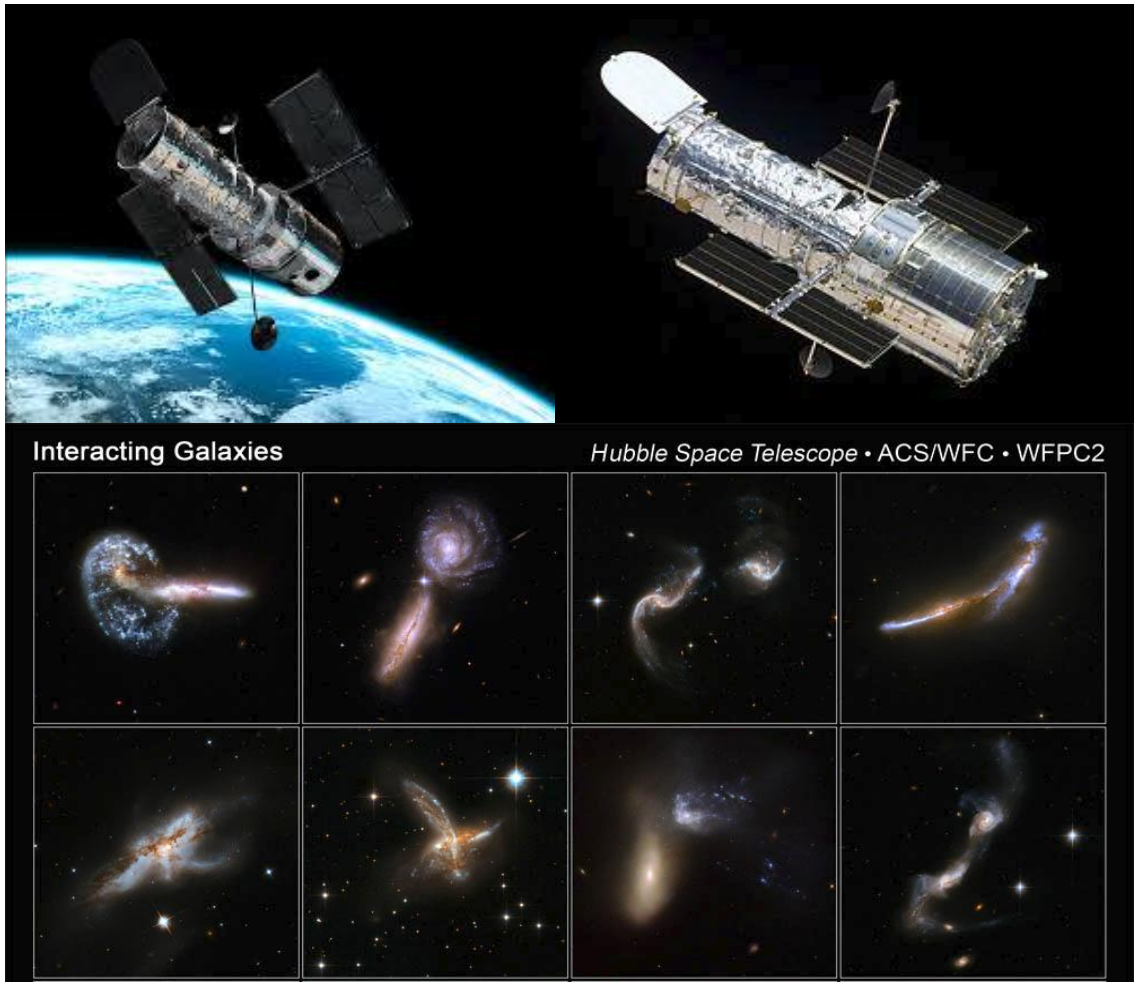
$$\text{Wavelength} = \frac{c}{\text{Frequency}}$$

where c is the speed of light

Telescope: Then and Now



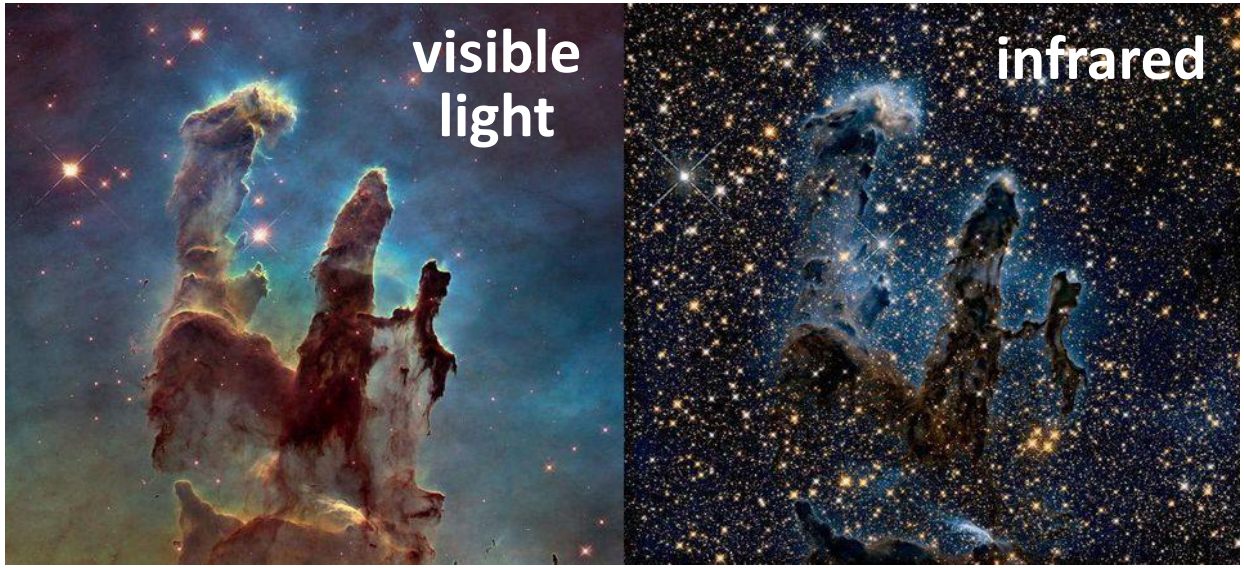
Two of **Galileo's first telescopes**, 10x and 20x and his ink rendering of the Moon.

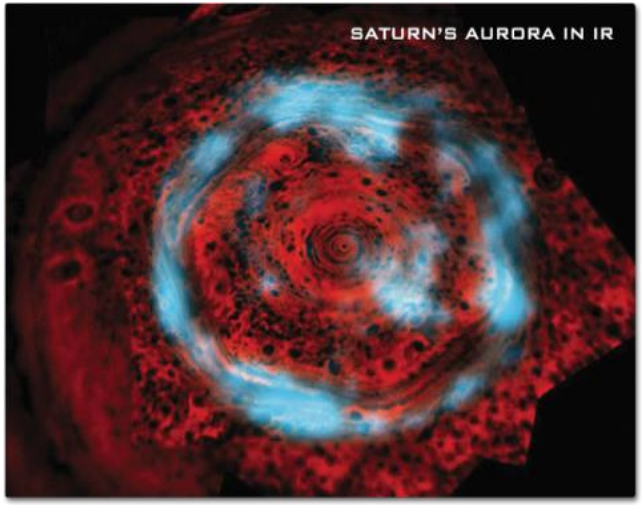


Hubble Space Telescope (launched in 1990), up to 4700x, allows observations in near-UV, visible, and near-IR spectra.

Infrared Advantage

- **IR** (longer wavelength) light passes more easily through dust clouds than visible light revealing faraway objects.

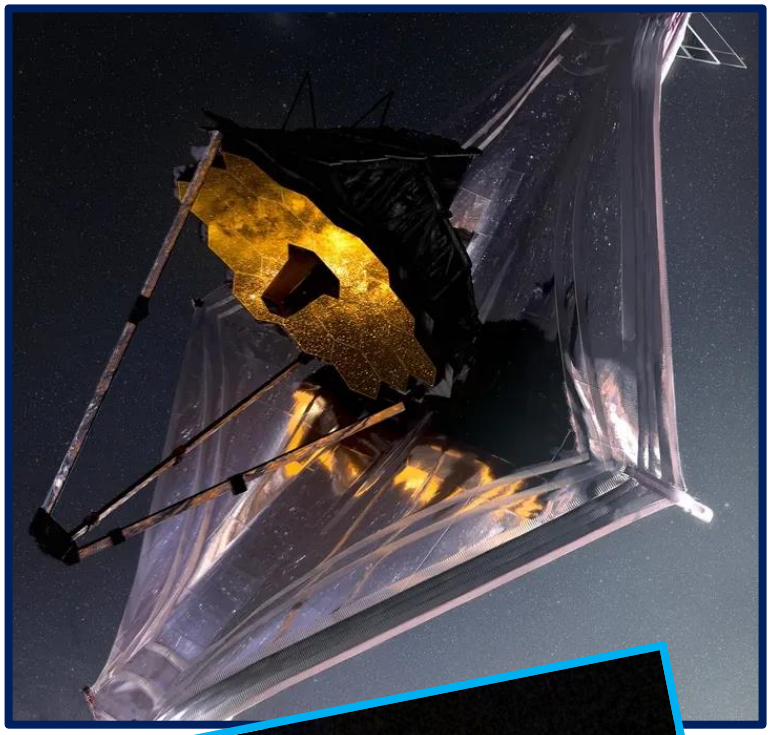


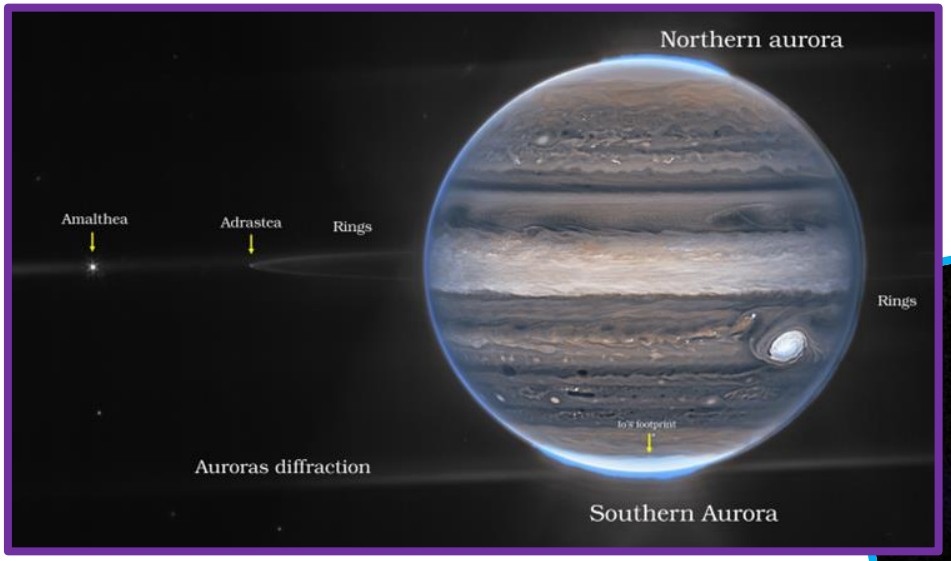


- **Very early and very distant** (*high-redshift*) objects have their visible emissions shifted into the infrared, and therefore their light can be observed only via infrared astronomy.
- **Colder objects** such as debris disks and planets emit most strongly in the infrared.

James Webb Telescope

The largest telescope in space, it is equipped with high-resolution and high-sensitivity instruments and operates in near- to mid-IR range.



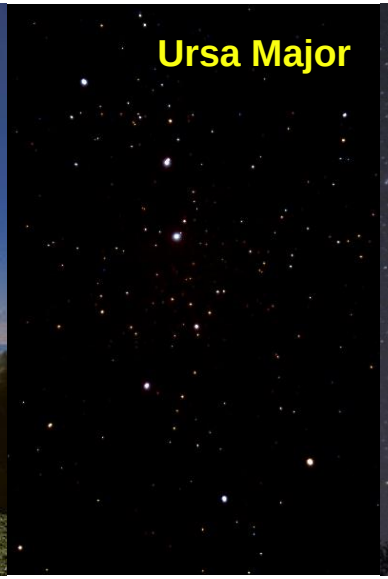


Jupiter with its inner (small) moons, rings, and aurorae

Neptune with some of its moons

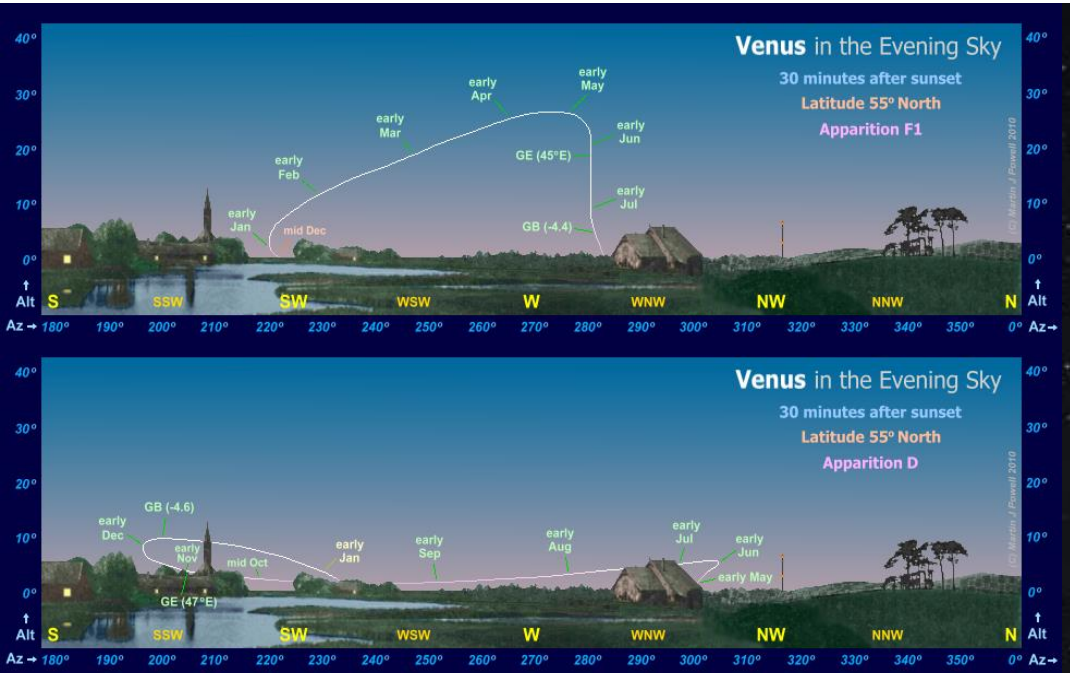
These are good enough still…

Observations from Earth



- **All objects in the heavens rise in the east and set in the west.**
- **The Sun and stars all move across the sky in a regular, predictable way. We can see several thousand stars easily!**
  - **The Sun travels around the sky in (about) 24 hours.**
  - **The stars travel around the sky slightly faster than the sun (23 hours and 56 minutes).**
- **Different stars are visible to different observers and the path they take is different. That would be the case for an observer on a spherical surface – this is a hint that the Earth is a sphere!**

Observations from Earth



Planets (Anc. Greek: "wandering star") move differently than the stars:

- **Mercury and Venus can only be seen near sunrise or sunset.**
- **Mars, Jupiter, and Saturn usually move slower than the stars…**
- **… but sometimes Mars, Jupiter, and Saturn move faster than the stars (so-called *retrograde* motion); retrograde motion varies slightly in when and how long it would last – this is a clue to the Solar System architecture and structure!**

Solar System