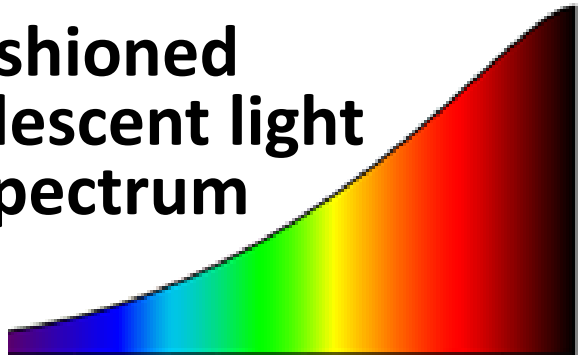
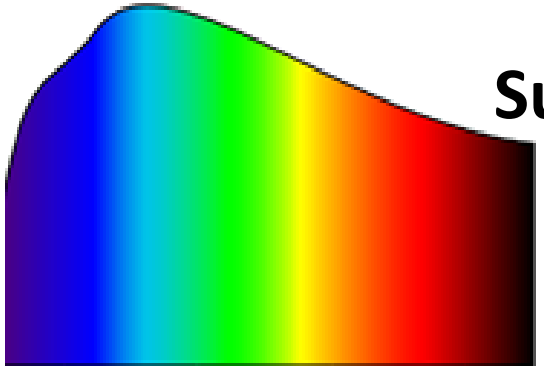
What color is this tulip? And why?

Indoor and outdoor *lighting* can be quite different!

Old-fashioned incandescent light bulb spectrum



has much more red+yellow than blue (giving the *sensation of orange*)

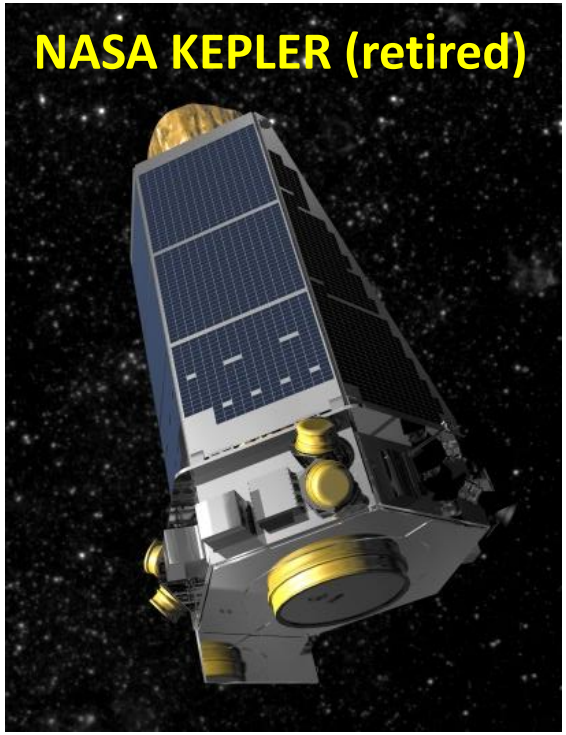


Sunlight spectrum

red and blue components are similar (giving the *sensation of pink*)

How to study Cosmos?

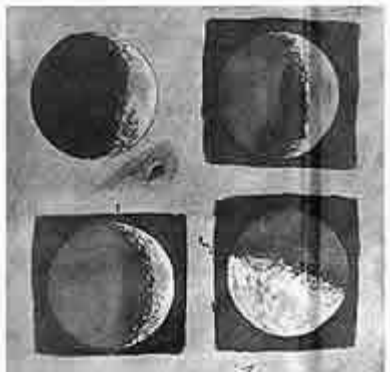
Just about everything we know about the Universe comes from the study of light emitted or reflected by objects in space.



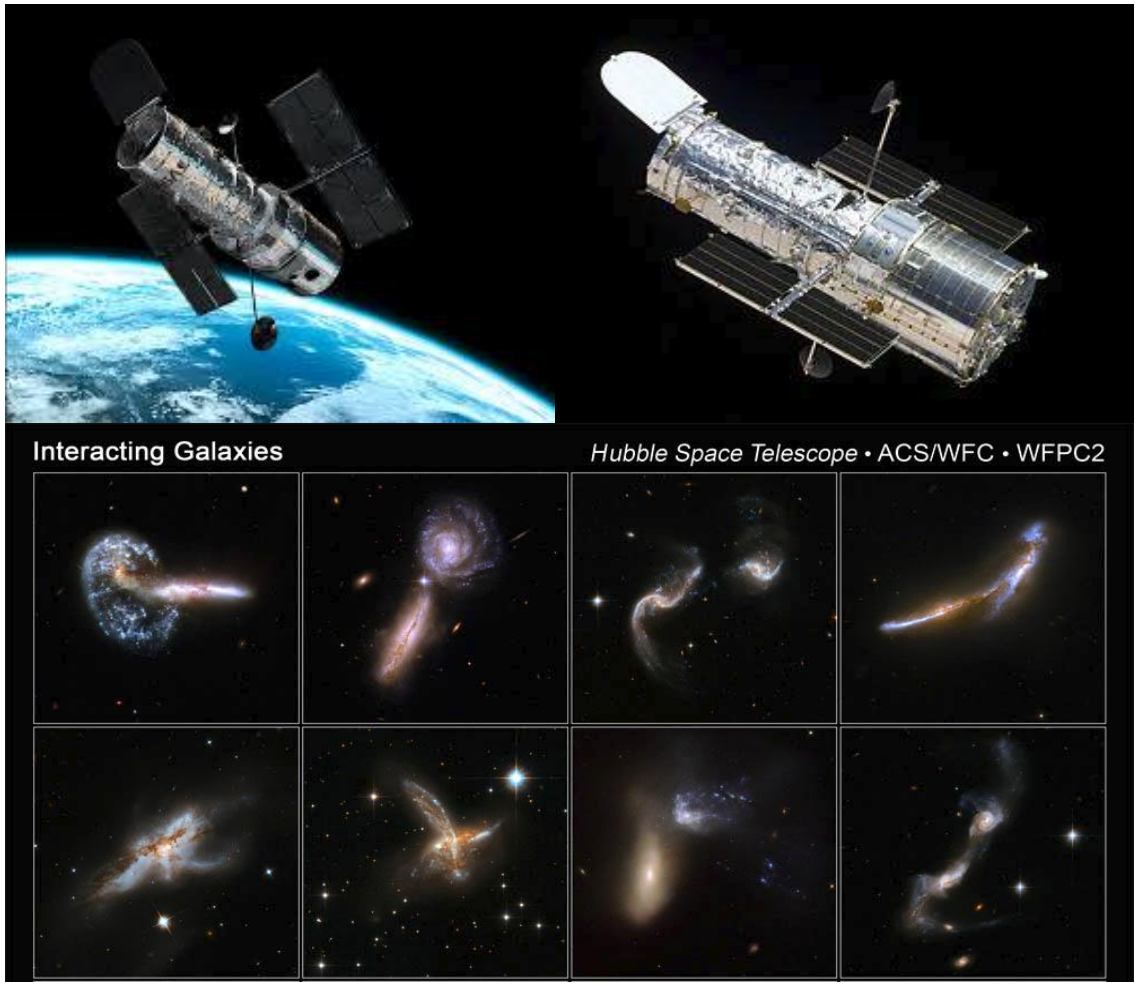
- **Telescopes** are used to gather light from distant objects and let us see them "up close". Astronomers use many different types of telescopes some of which are located right here on Earth and some are sent into space.

- **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.

Telescope: Then and Now



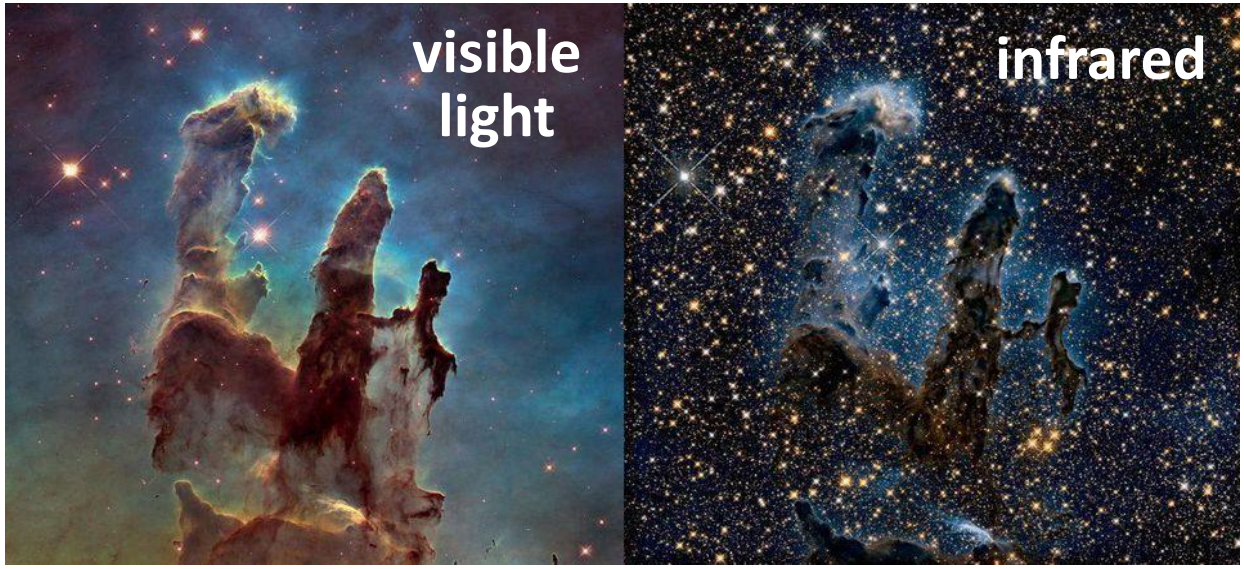
Two of **Galileo's first telescopes**, 10x and 20x and his ink rendering of the Moon.

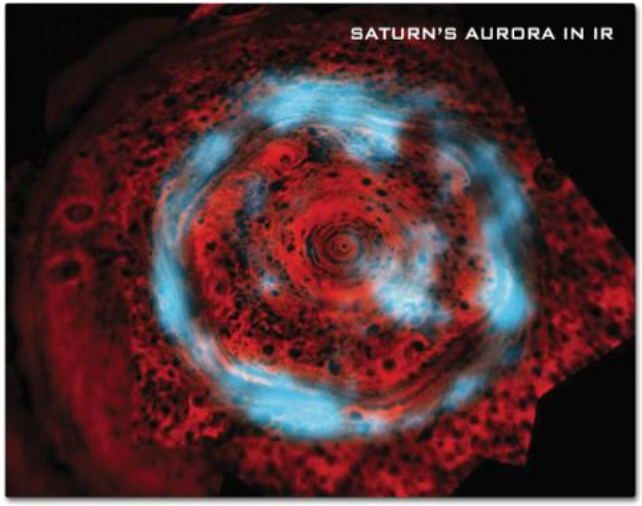


Hubble Space Telescope (launched in 1990), up to 4700x, allows observations in near-UV, visible, and near-IR spectra.

Infrared Advantage

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

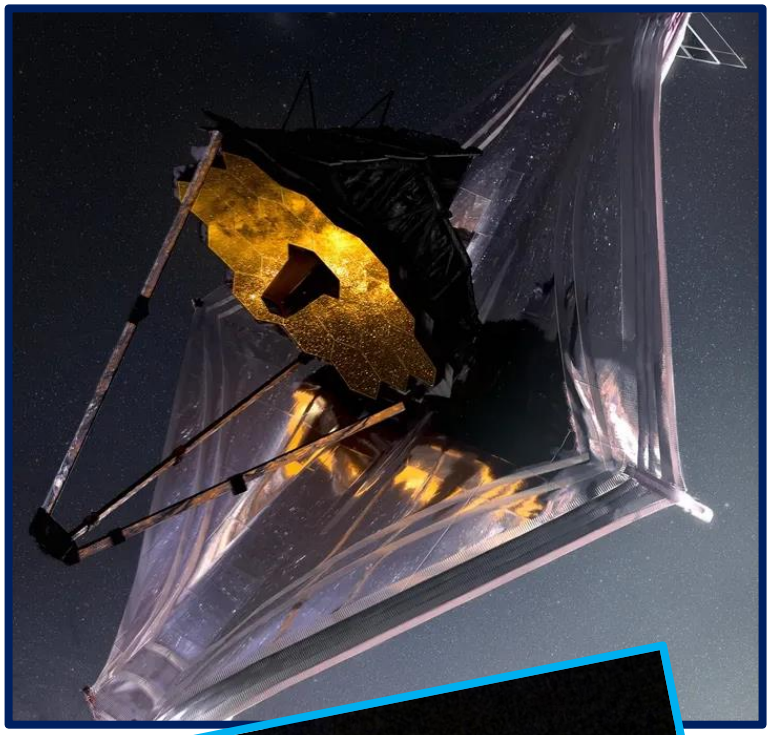


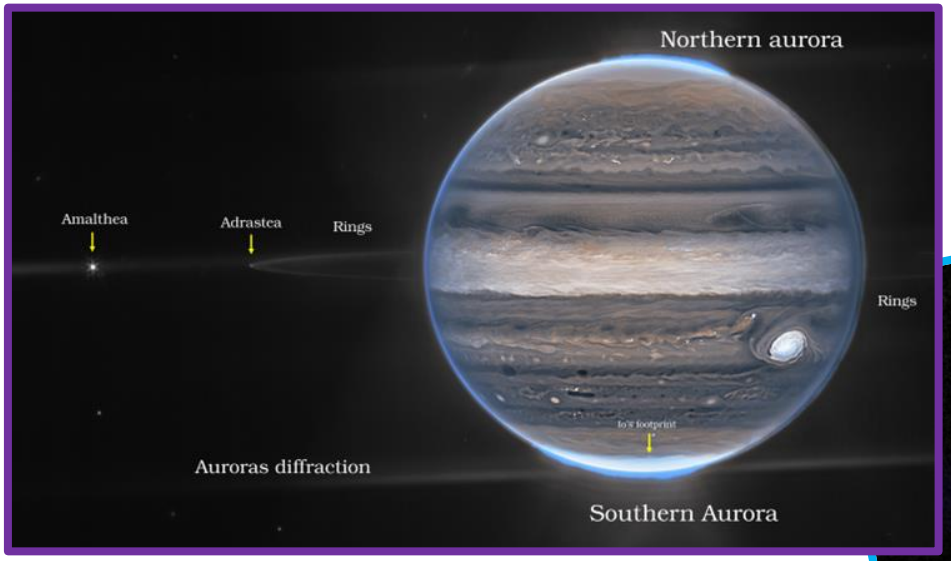


- **Very early and very distant** (*high-redshift*) objects have their visible emissions shifted into the infrared, and therefore their light can be observed only via infrared astronomy.
- **Colder objects** such as debris disks and planets emit most strongly in the infrared.

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…