CAASTRO
ALL-SKY ASTROPHYSICS

@astro_stephi

# Telescopes

CAASTRO in the Classroom: National Science Week 2017

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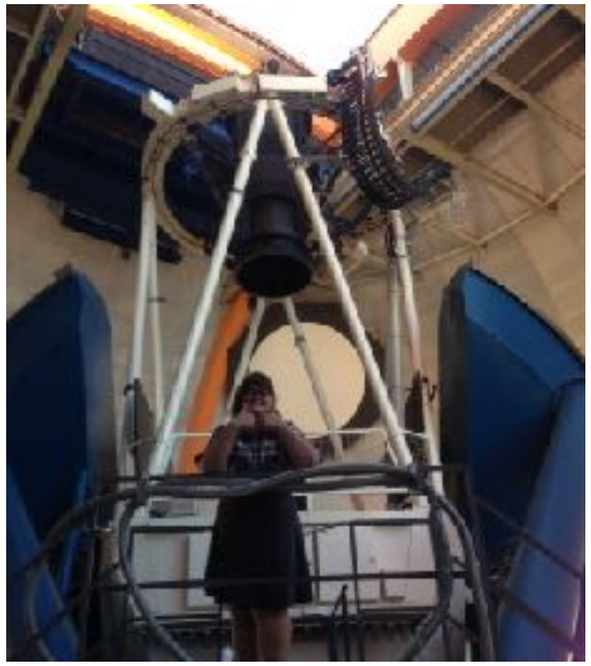
# About me




# The first telescopes

- ★ Invented in 1600s in the Netherlands

- ★ **Refracting** telescopes use lenses to bend light

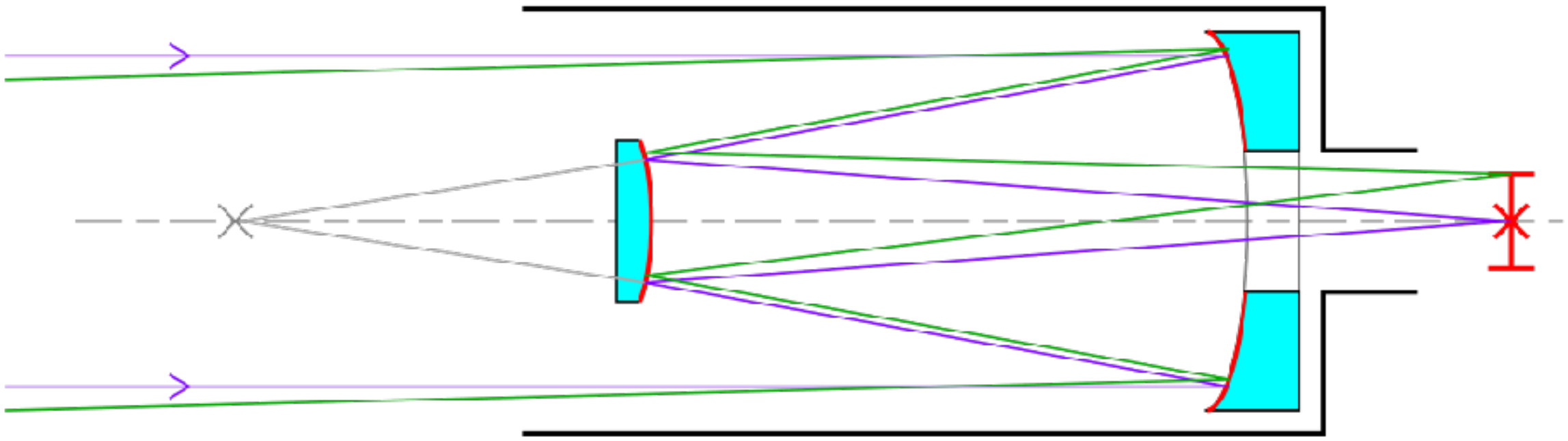
- ★ Refractors are very long and unwieldy

# The first telescopes

- ★ Galileo improved telescope design and discovered four moons around Jupiter in 1610
- ★ Used his telescope to look at the Moon – determined that dark and light patches were due to cratering

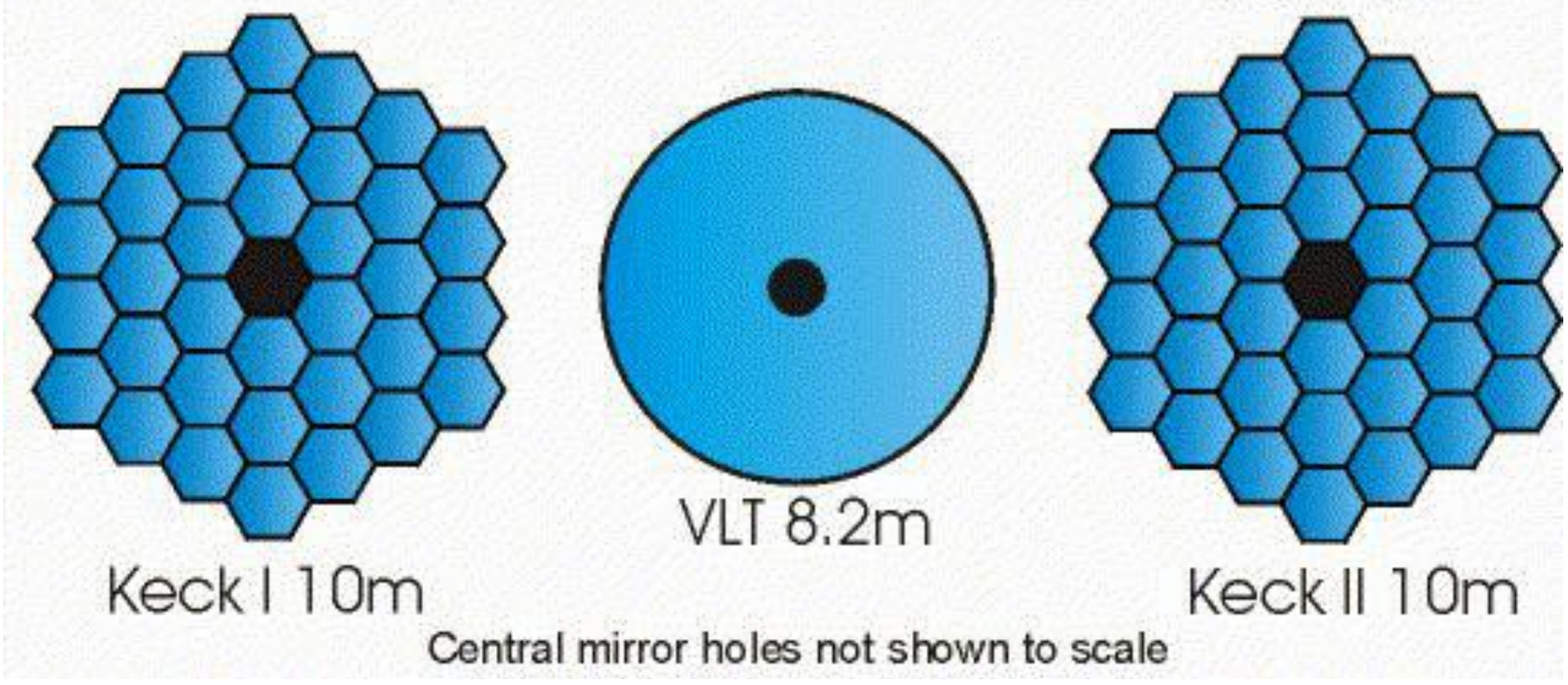
# The first telescopes

- ⋆ **Reflecting** telescopes use mirrors to reflect light – can be much larger than refracting telescopes



# Modern telescopes

- ★ Largest reflecting telescopes are 8-10 m in diameter – glass is too heavy for larger mirrors, they have to be segmented

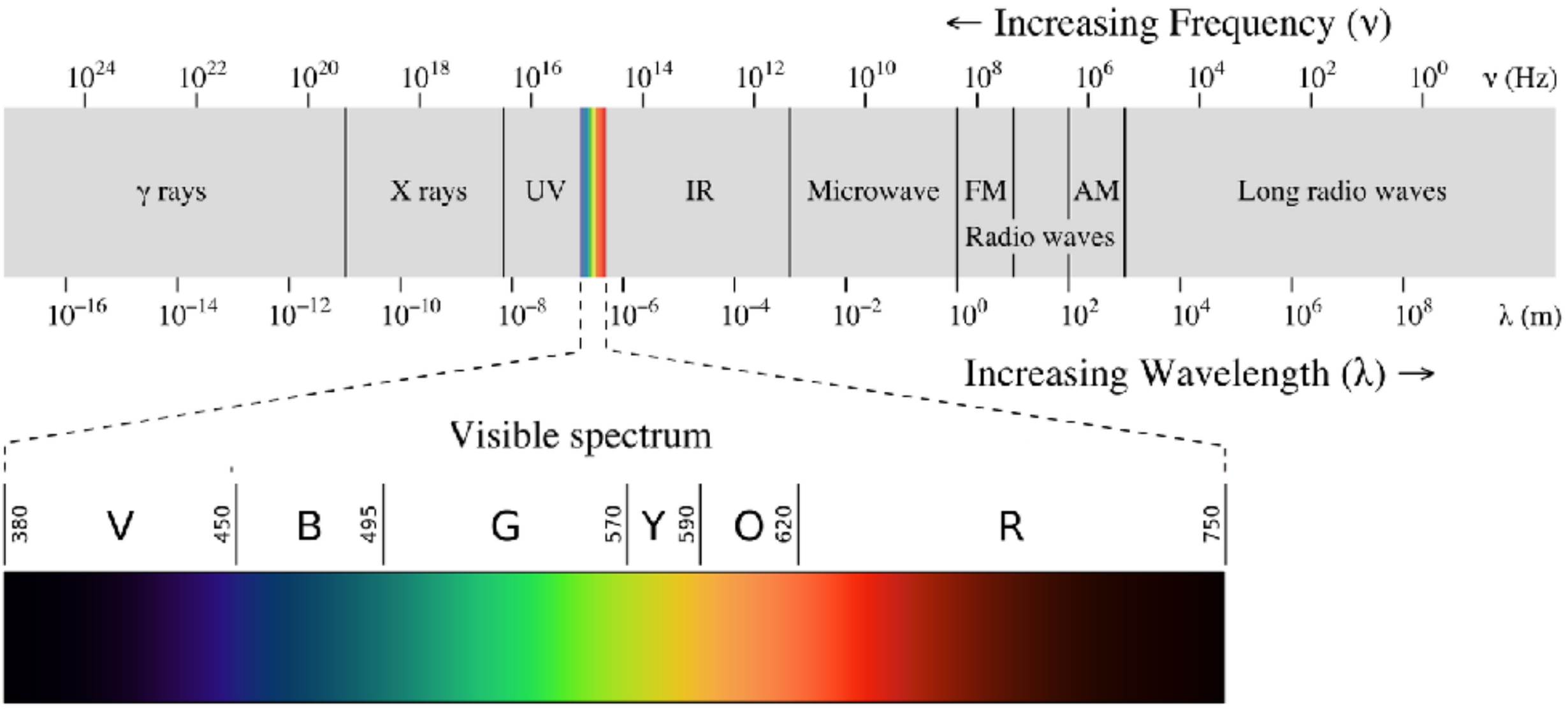


# Light

★ Light is both a particle (photon) and a wave – called **electromagnetic radiation**

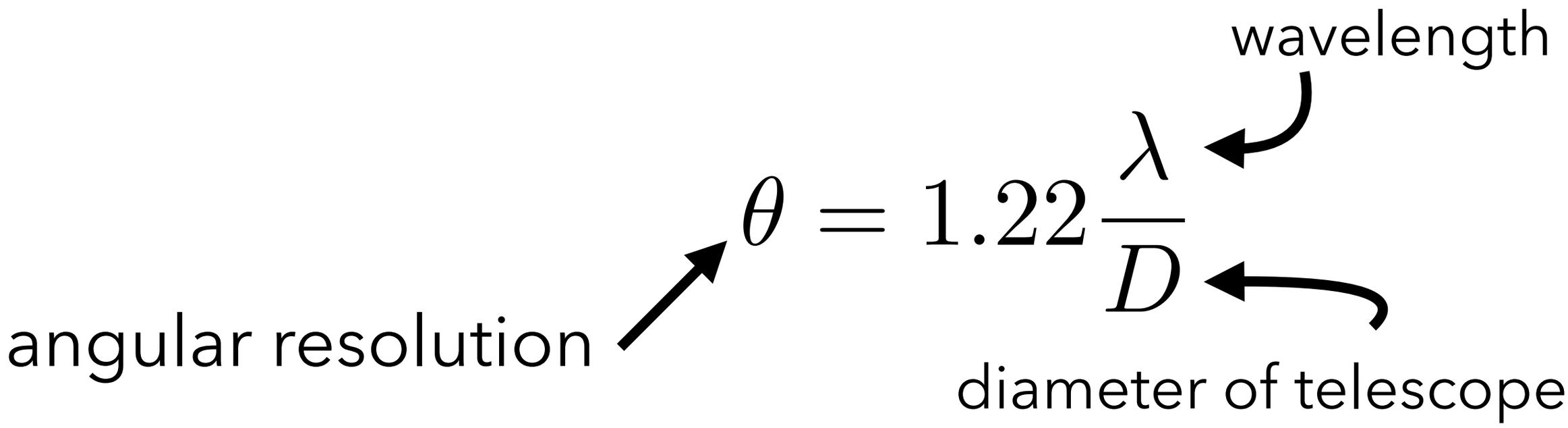
★ Different energies of light have different wavelengths and frequencies

# Light


← Increasing Frequency (ν)
10^24 10^22 10^20 10^18 10^16 10^14 10^12 10^10 10^8 10^6 10^4 10^2 10^0 ν (Hz)
γ rays
X rays
UV
IR
Microwave
FM
AM
Radio waves
Long radio waves
10^-16 10^-14 10^-12 10^-10 10^-8 10^-6 10^-4 10^-2 10^0 10^2 10^4 10^6 10^8 λ (m)
Increasing Wavelength (λ) →
Visible spectrum
380
V
450
B
495
G
570
Y
590
O
620
R
750

# Resolution

★ **Resolution** of telescope depends on wavelength and size of mirror



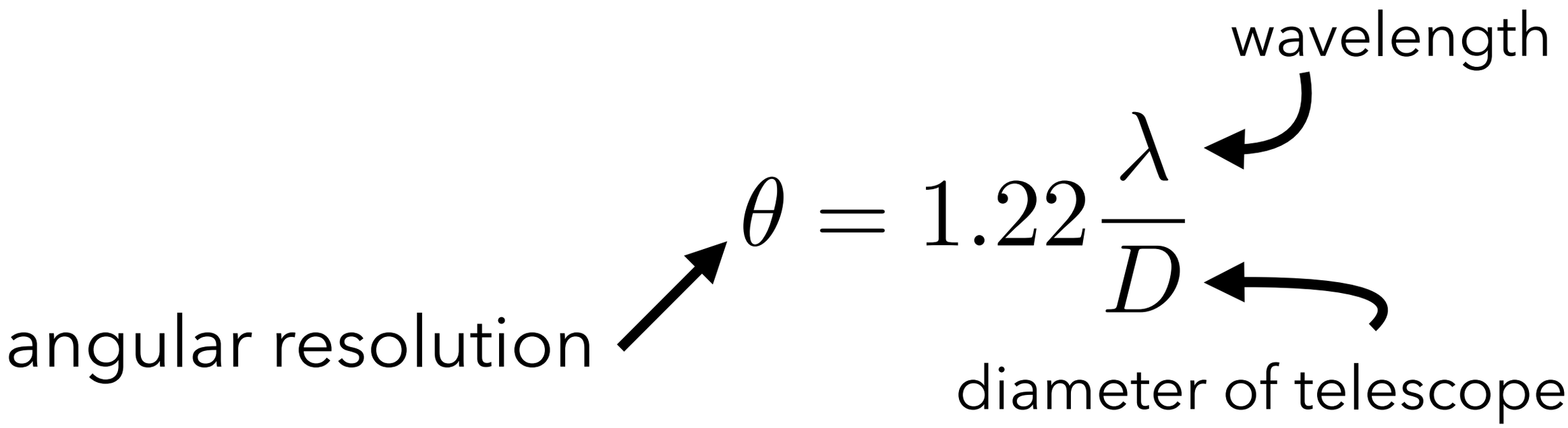
# Resolution

★ Larger diameter telescope

→ smaller angle = better resolution

★ Longer wavelength

→ larger angle = worse resolution



# Resolution

★ Optical telescopes (λ = 350 – 850 nm) – telescopes are a few metres in diameter

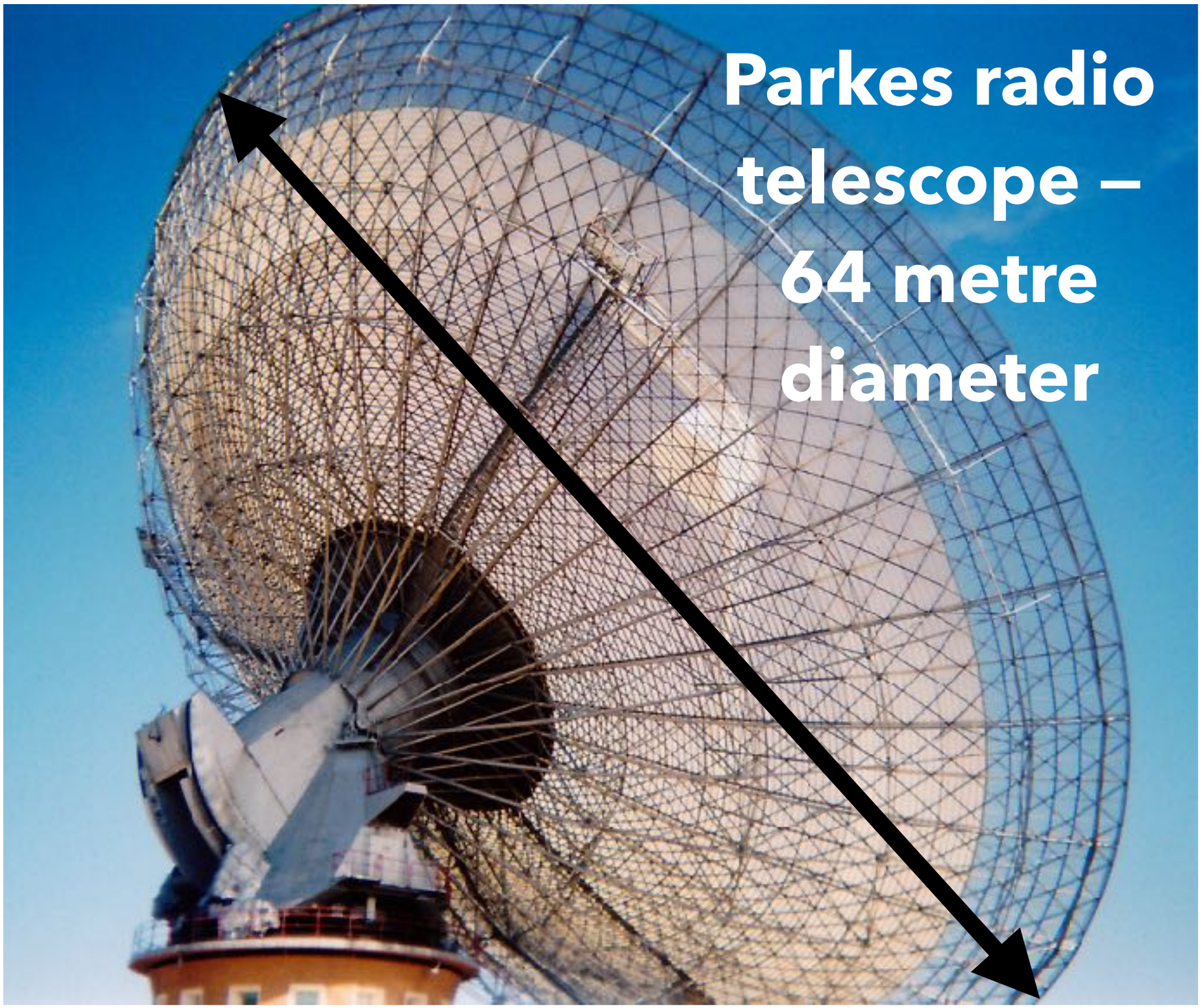
★ Radio telescopes (λ = several metres) – telescopes are dozens to hundreds of metres in diameter

$$\theta = 1.22 \frac{\lambda}{D}$$

angular resolution

wavelength

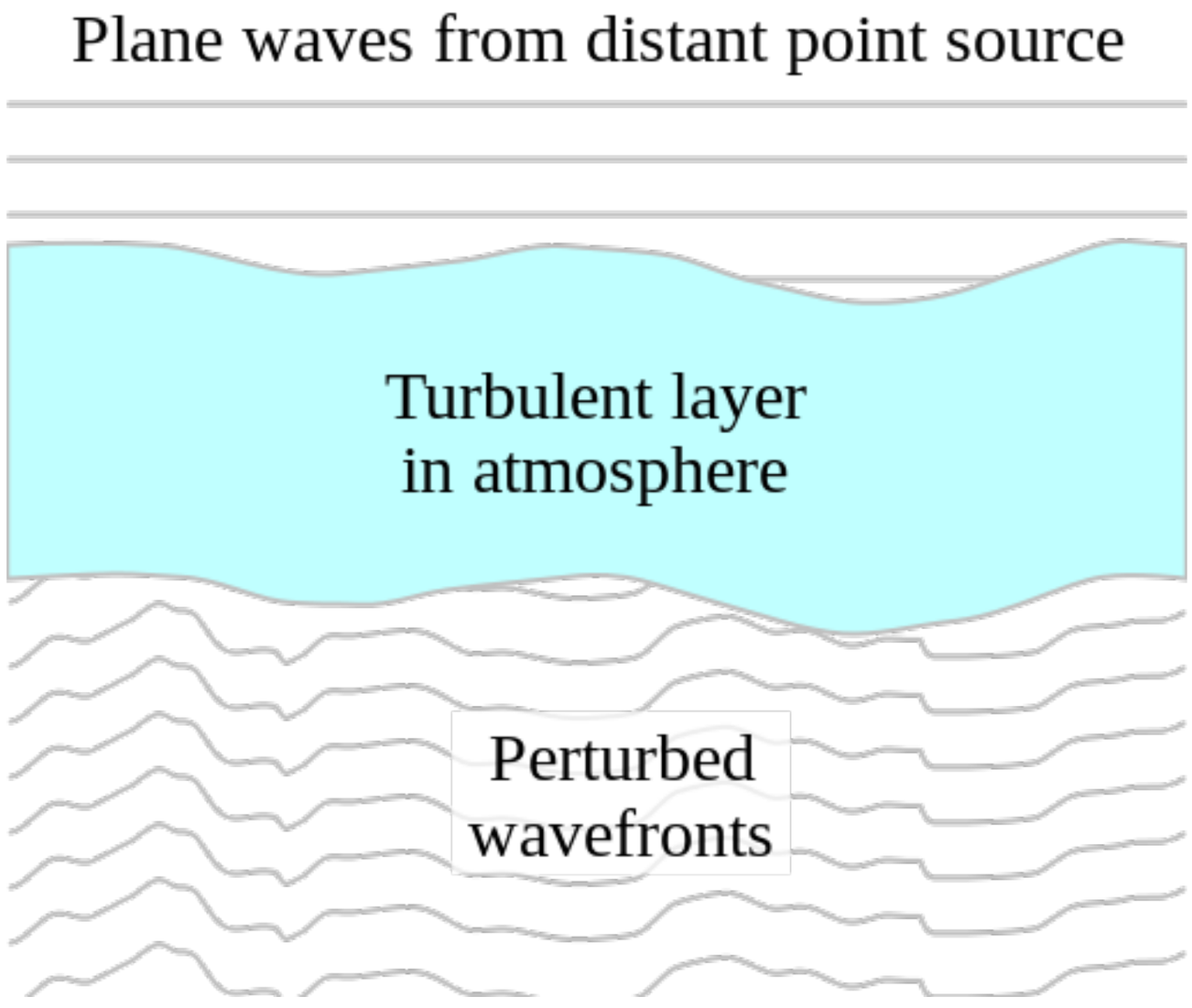
diameter of telescope




Radio telescopes are often used simultaneously – even on opposite sides of the Earth!

# Ground-based

- ⋆ Telescopes on the ground have to look through the atmosphere
- ⋆ The atmosphere is turbulent and blurs the light coming from a source – called **seeing**



# Ground-based

- ★ The atmosphere is also only transparent to certain wavelengths – molecules in the atmosphere like water absorb light

- ★ Optical and radio wavelengths can get through but ultraviolet and infrared wavelengths are blocked

# Space-based

- ★ Space-based telescopes can detect wavelengths that are blocked by the atmosphere

- ★ The light doesn't get blurred – better resolution

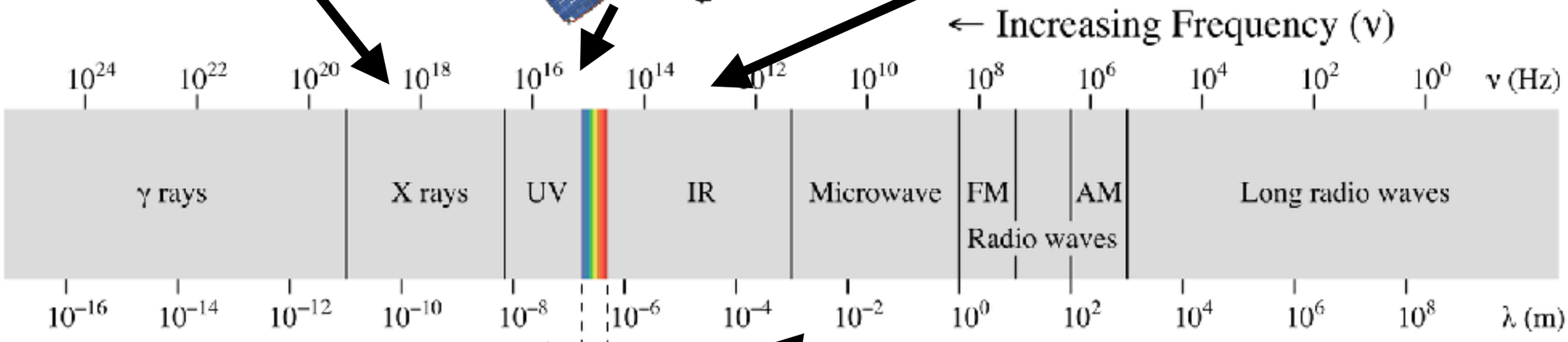
# Space telescopes

Chandra X-ray Observatory

Swift

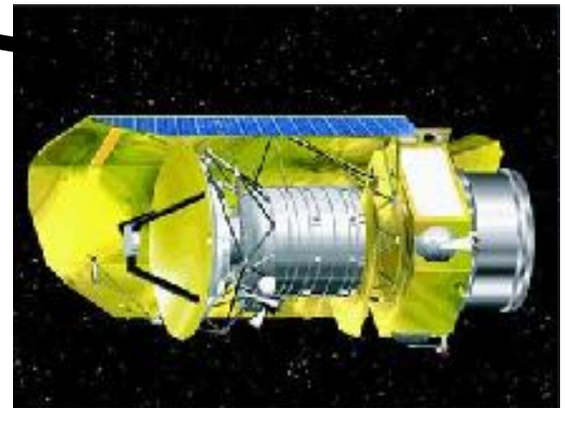
Spitzer Space Telescope

Images: NASA, ESA




Fermi gamma-ray Space Telescope

Hubble Space Telescope

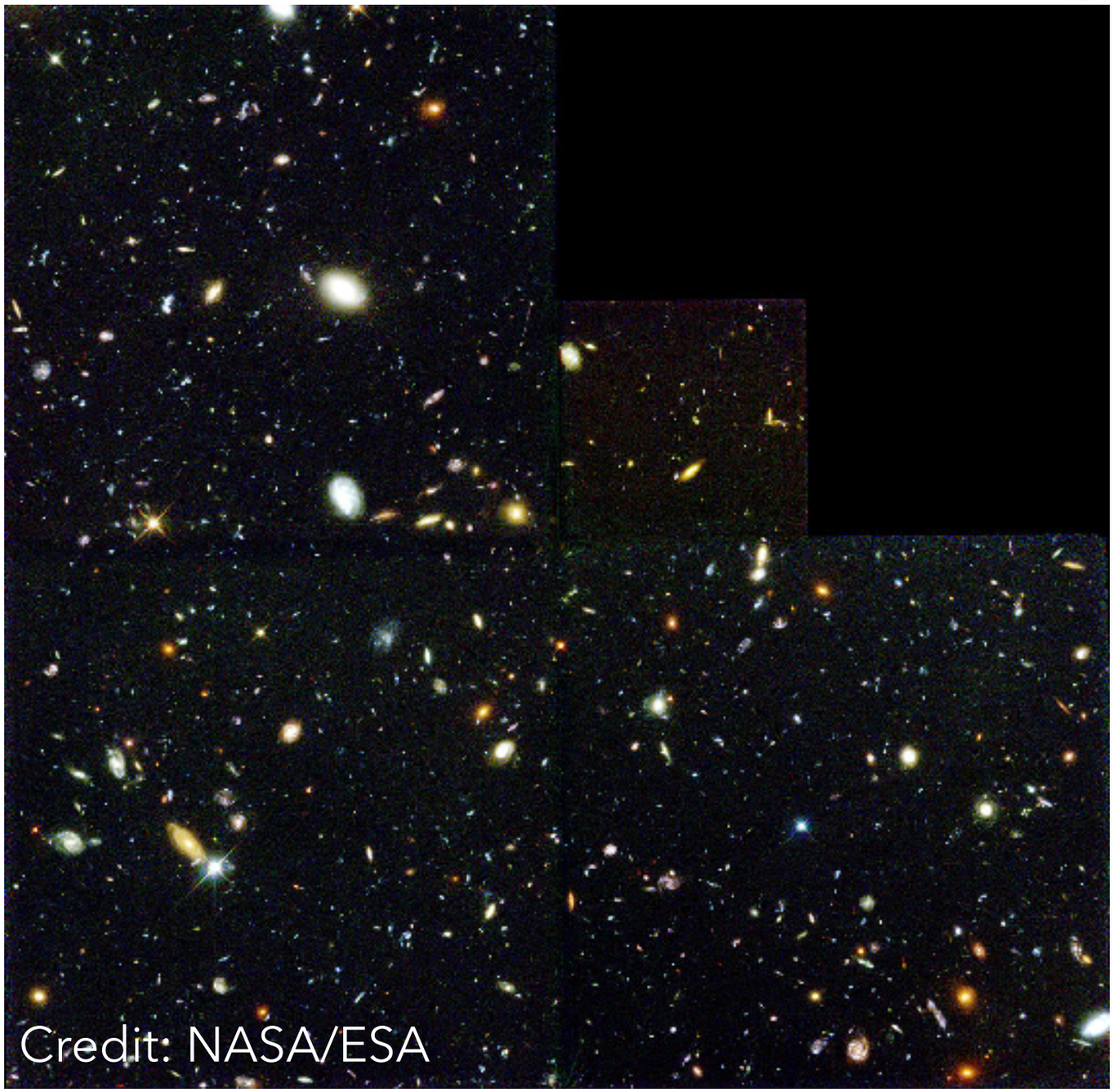


Herschel Space Observatory

# Images

- ★ Images tell us where sources are on the sky

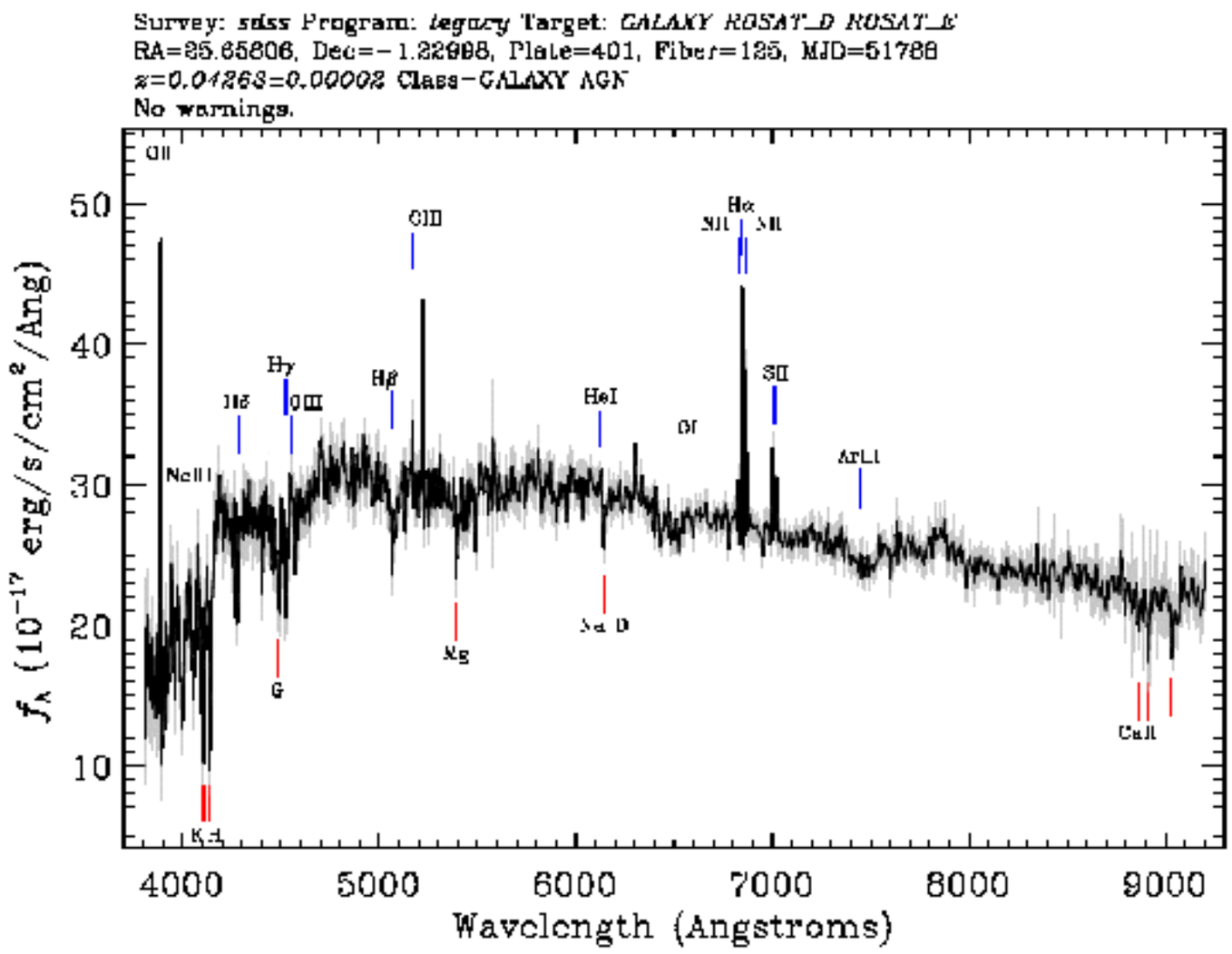
- ★ Use filters to look at only certain wavelengths




Hubble Deep field

# Spectra

- ★ By splitting the light into different wavelengths we can look at the spectrum of the object
- ★ Sources can emit more light at particular wavelengths or absorb only particular wavelengths




Spectrum of a galaxy

# Data

★ Use imaging and spectroscopy together to get information about sources like stars and galaxies

★ Imaging first to find **where** sources are

★ Spectroscopy then tells us things like **what** the source is made of, **how far away** it is

# Surveys

- ⋆ To get data, we use telescopes to perform surveys
- ⋆ Telescopes can be dedicated to particular surveys, e.g. Sloan Digital Sky Survey
- ⋆ Or telescopes can be open to astronomers who propose to use part of the telescope's time to look at particular sources

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# Surveys

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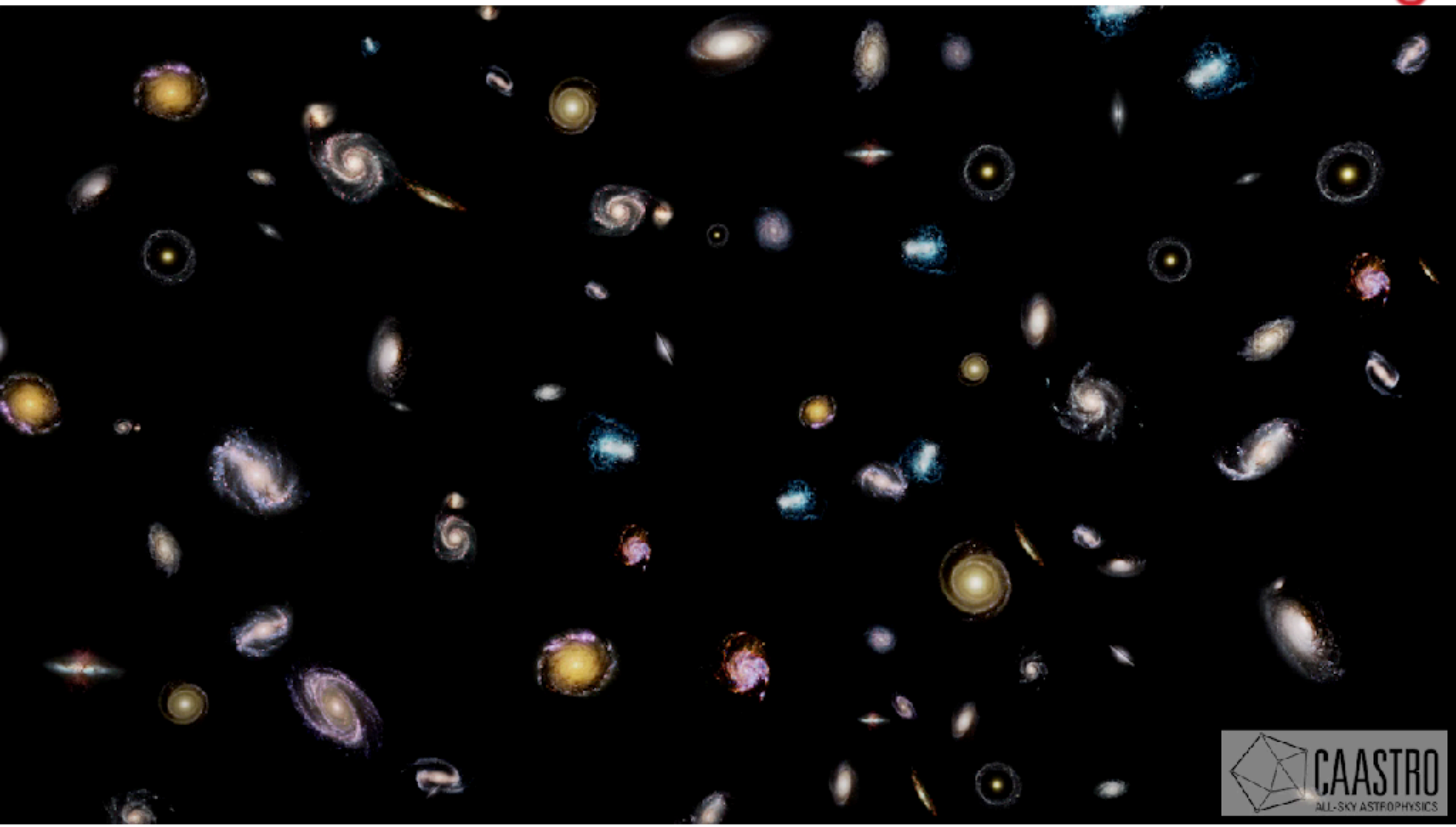

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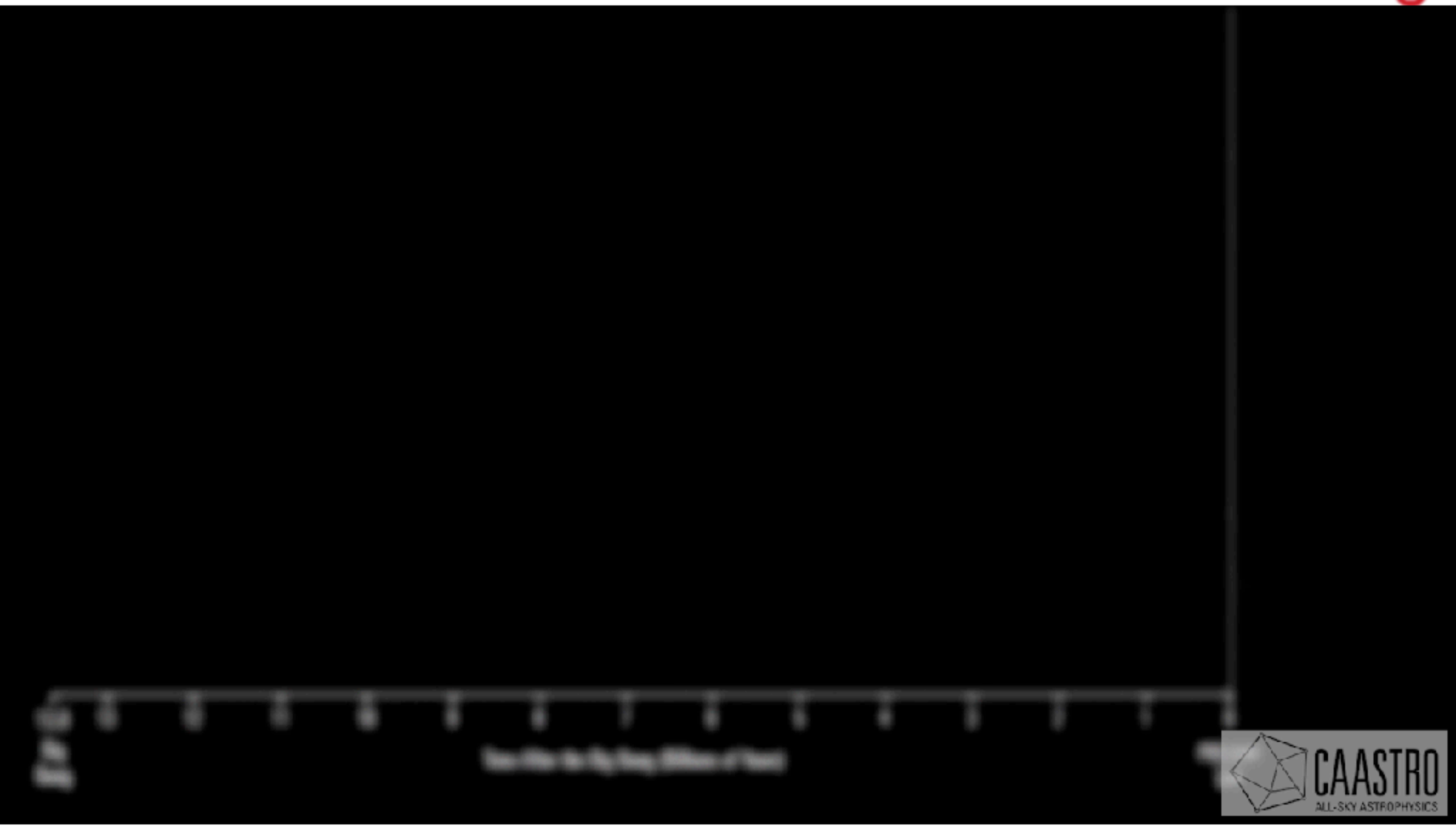
# Redshift of a Photon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