



# Summary:

- EM Spectrum
- Spectra
- Blackbodies + Wien's Law
- Spectroscopy
- Spectral Types
- Luminosity and the inverse square law
- Variation in Luminosity



# Solar Radiation

and Habitable Zones



# Recap



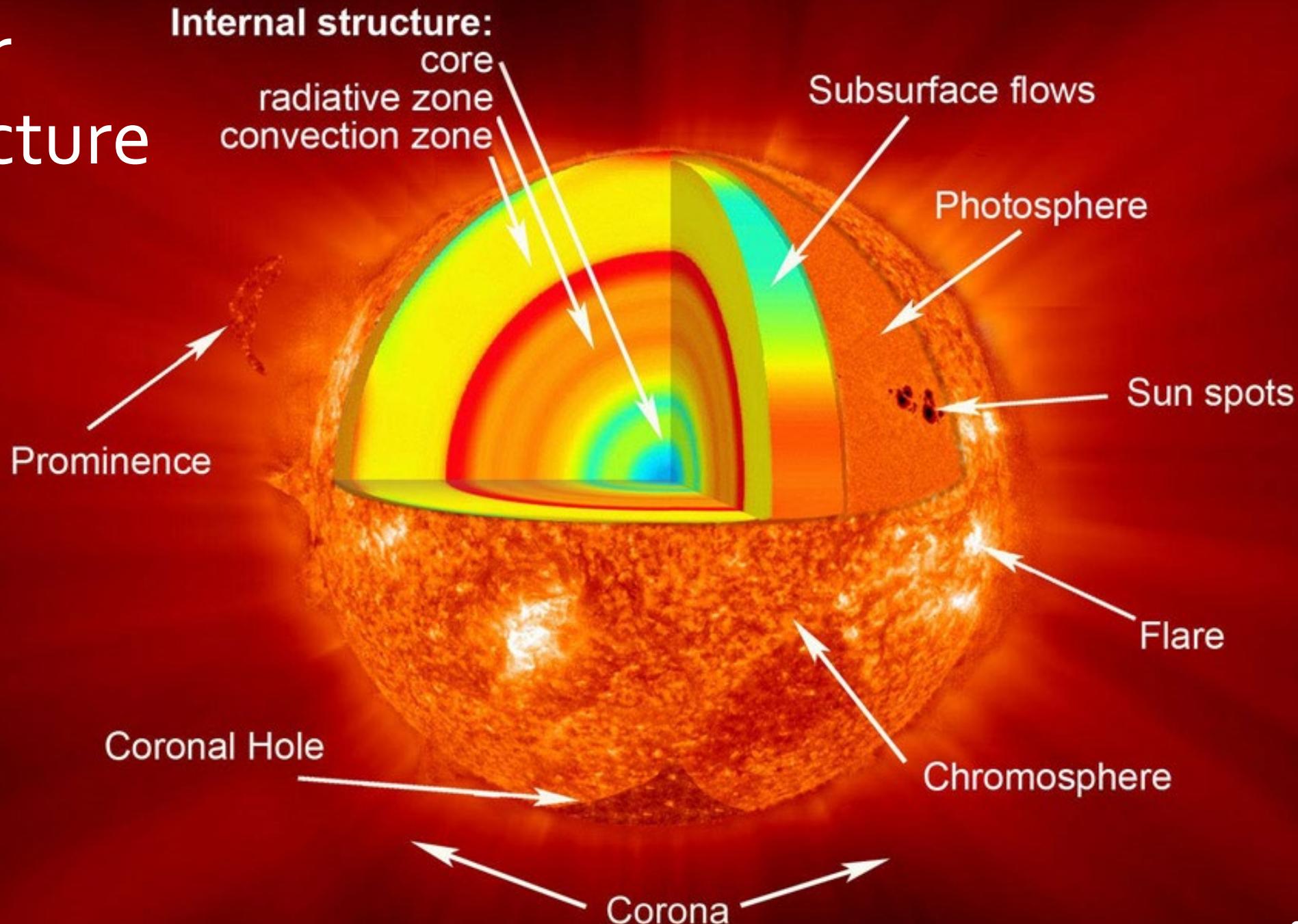
1. Name as many layers of the Sun. Deepest first.
2. Name three features on the Sun's surface.
3. What can we only observe during a solar eclipse?



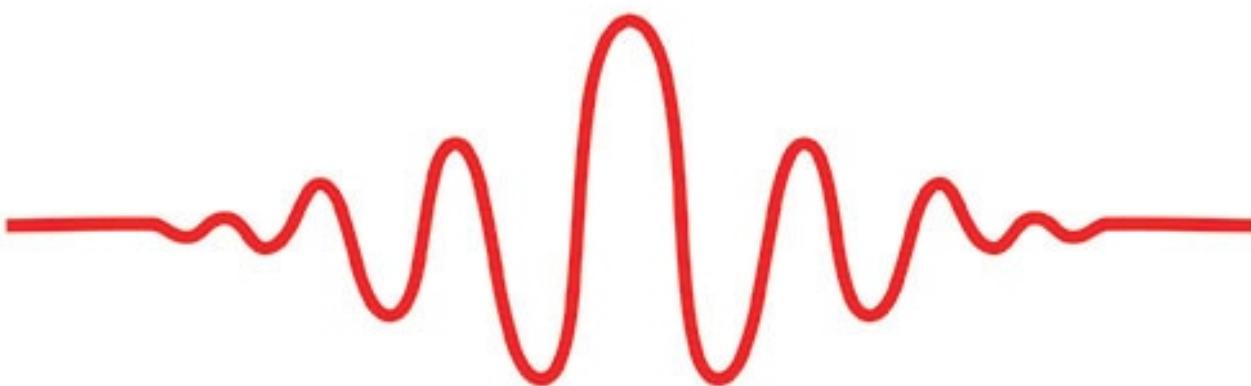
# Solar Structure

## Internal structure:

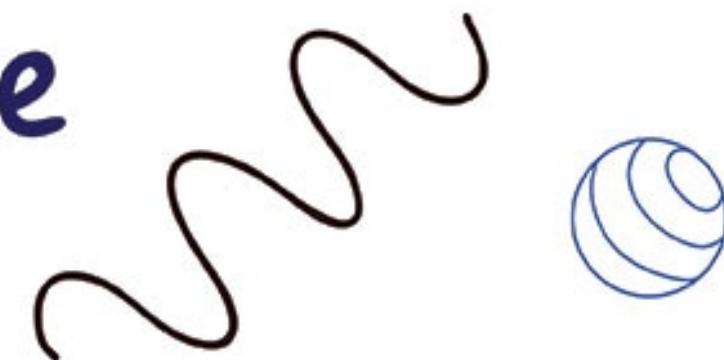
core  
radiative zone  
convection zone



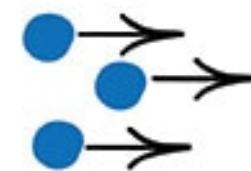
# Wave - Particle Duality



wave

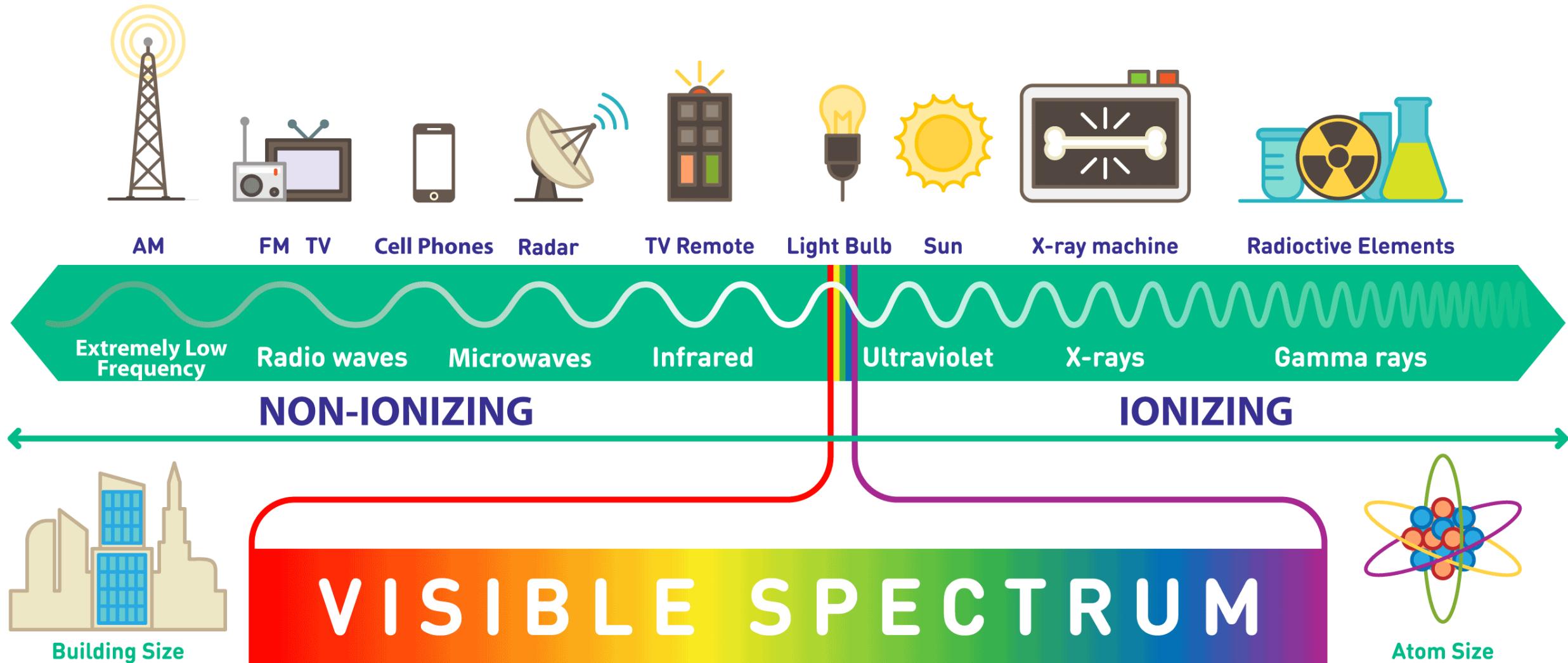


$$c = 299\,792\,458 \text{ m/s}$$



particle

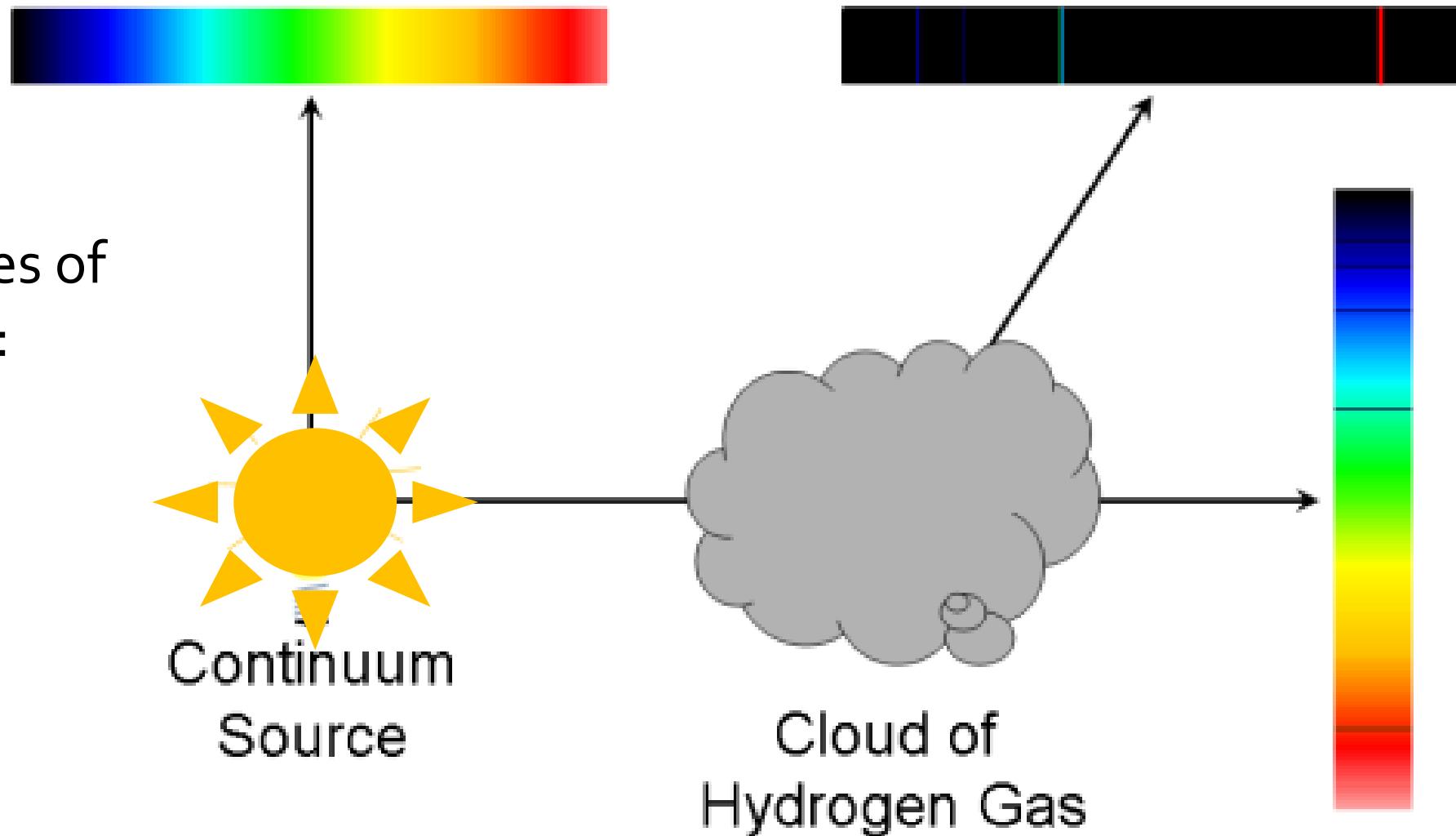
# Electromagnetic Spectrum



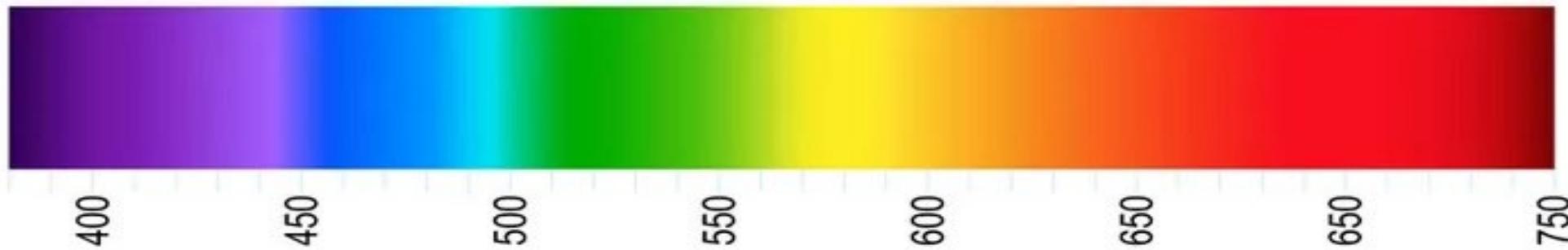
# Spectra

There are three types of spectra shown here:

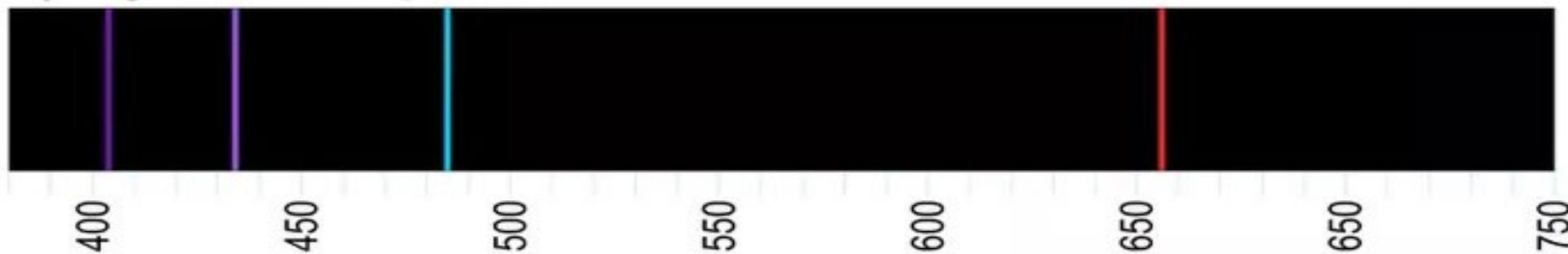
- Continuous
- Emission
- Absorption



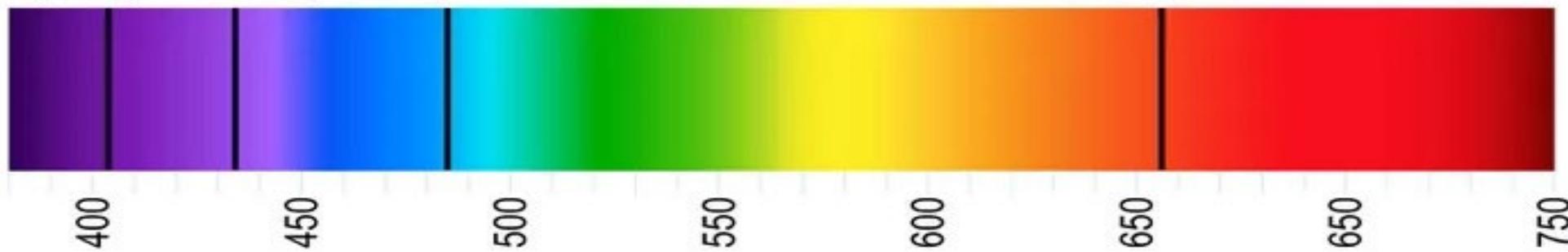
Continuous spectrum



Hydrogen Emission spectrum



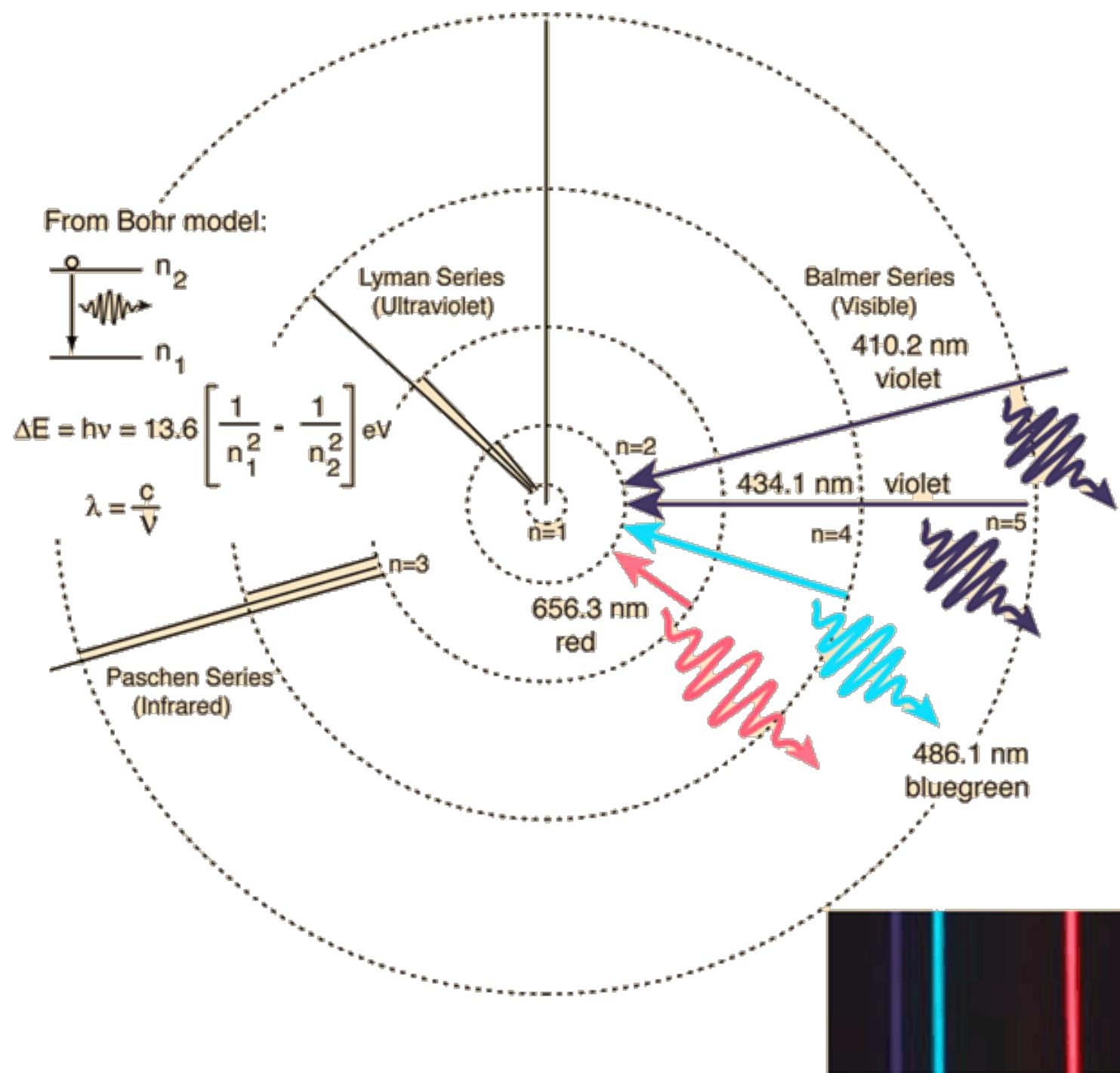
Hydrogen Absorption spectrum



# Spectra

This shows the energy levels of Hydrogen.

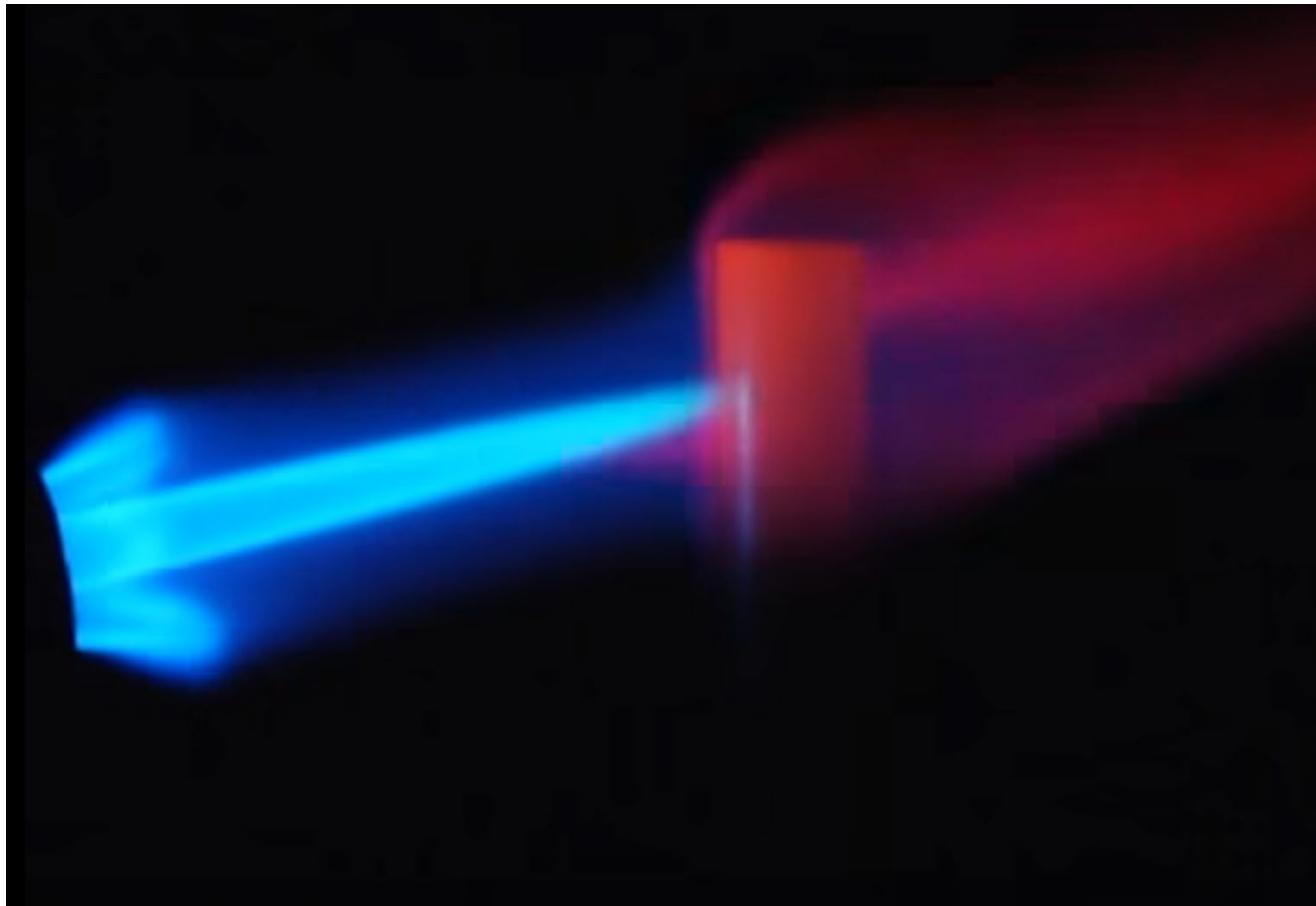
The Balmer Series on the right is the visible light emission.



# Generating Light

Light can be generated by:

- Charges that are accelerating
- Heating an object up  
(Thermal Radiation)
- Fusion



# Blackbody Radiation

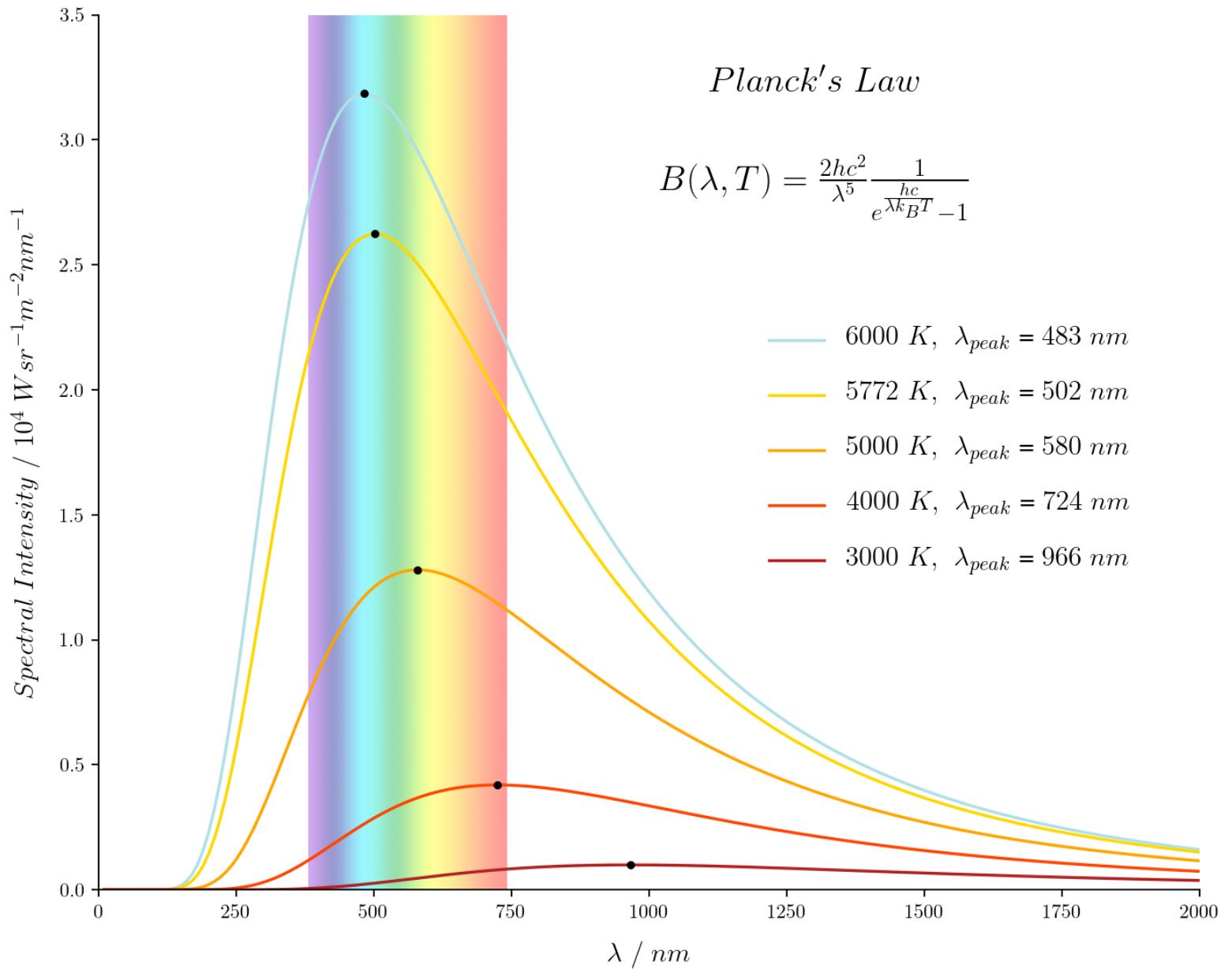
A blackbody absorbs all incident radiation and emits all radiation perfectly.

No real object is a perfect blackbody.

*Radiation Curves for different Temperatures*

*Planck's Law*

$$B(\lambda, T) = \frac{2hc^2}{\lambda^5} \frac{1}{e^{\frac{hc}{\lambda k_B T}} - 1}$$



# Wien's Law

A hotter object emits more high energy radiation.

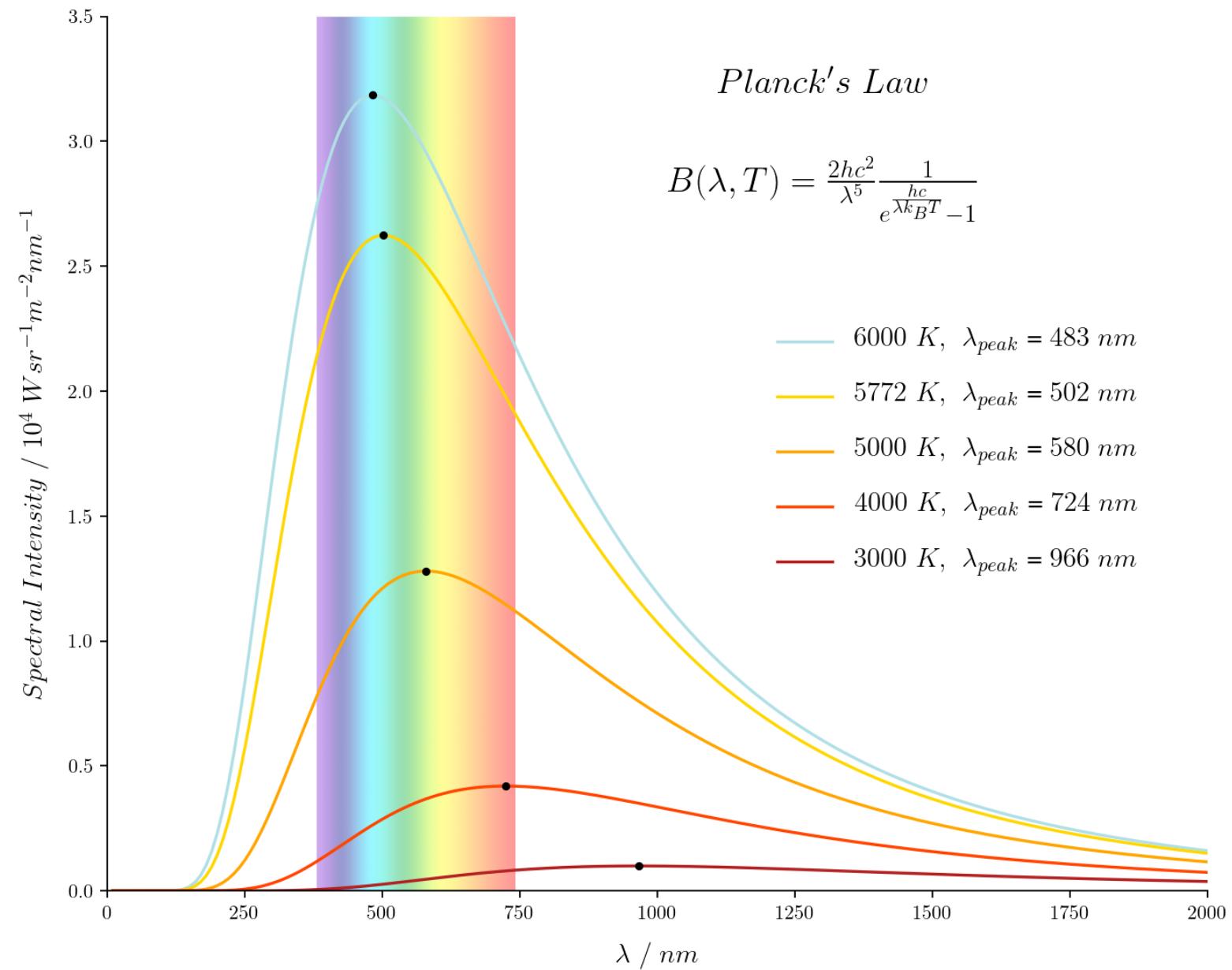
$$\lambda_{peak} = \frac{b}{T}$$

We can find the wavelength the object emits most using Wien's Law.

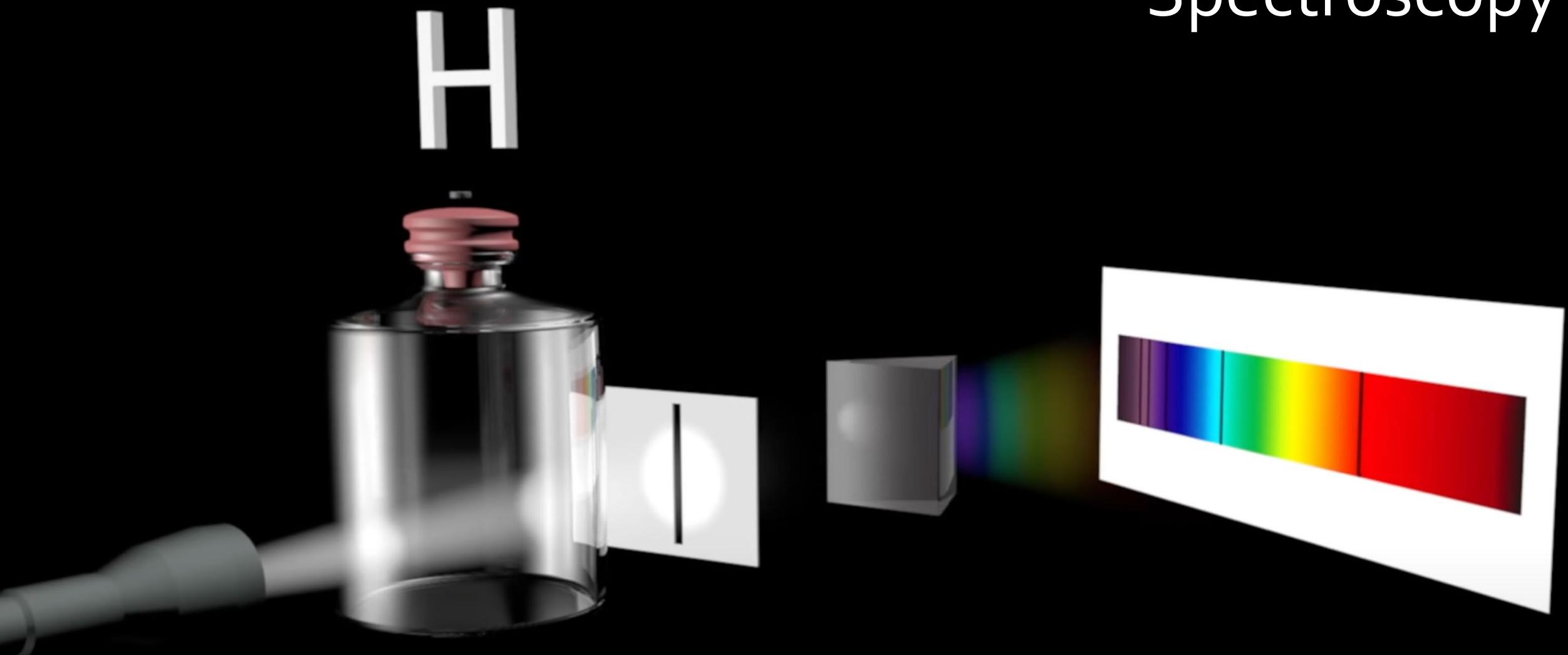
*Radiation Curves for different Temperatures*

*Planck's Law*

$$B(\lambda, T) = \frac{2hc^2}{\lambda^5} \frac{1}{e^{\frac{hc}{\lambda k_B T}} - 1}$$



# Spectroscopy



## AstroSims > Spectrum constructor

Continuous spectrum:

None  
 Visible  
 Thermal  K  


% of c

km/s  

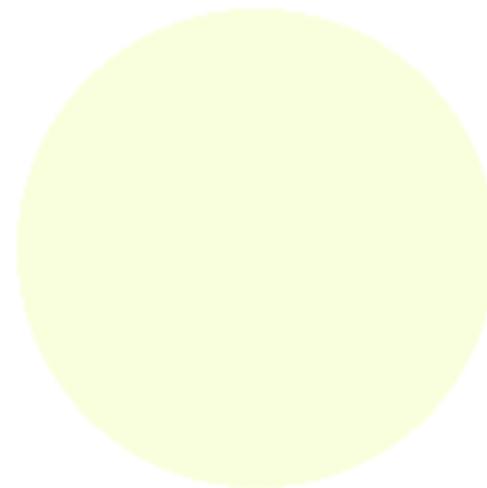

Emission spectra:

- Hydrogen
- Helium
- Lithium
- Sodium
- Mercury
- Neon

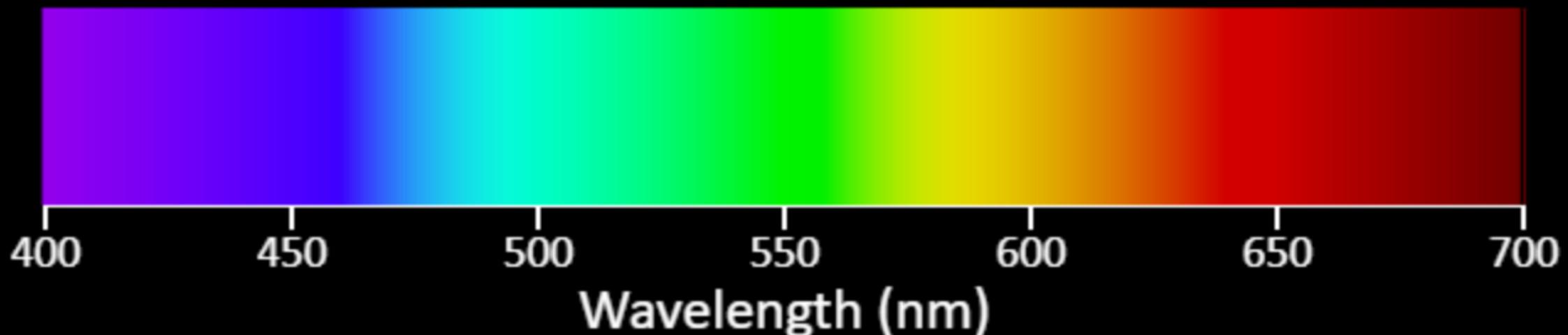
Absorption spectra:

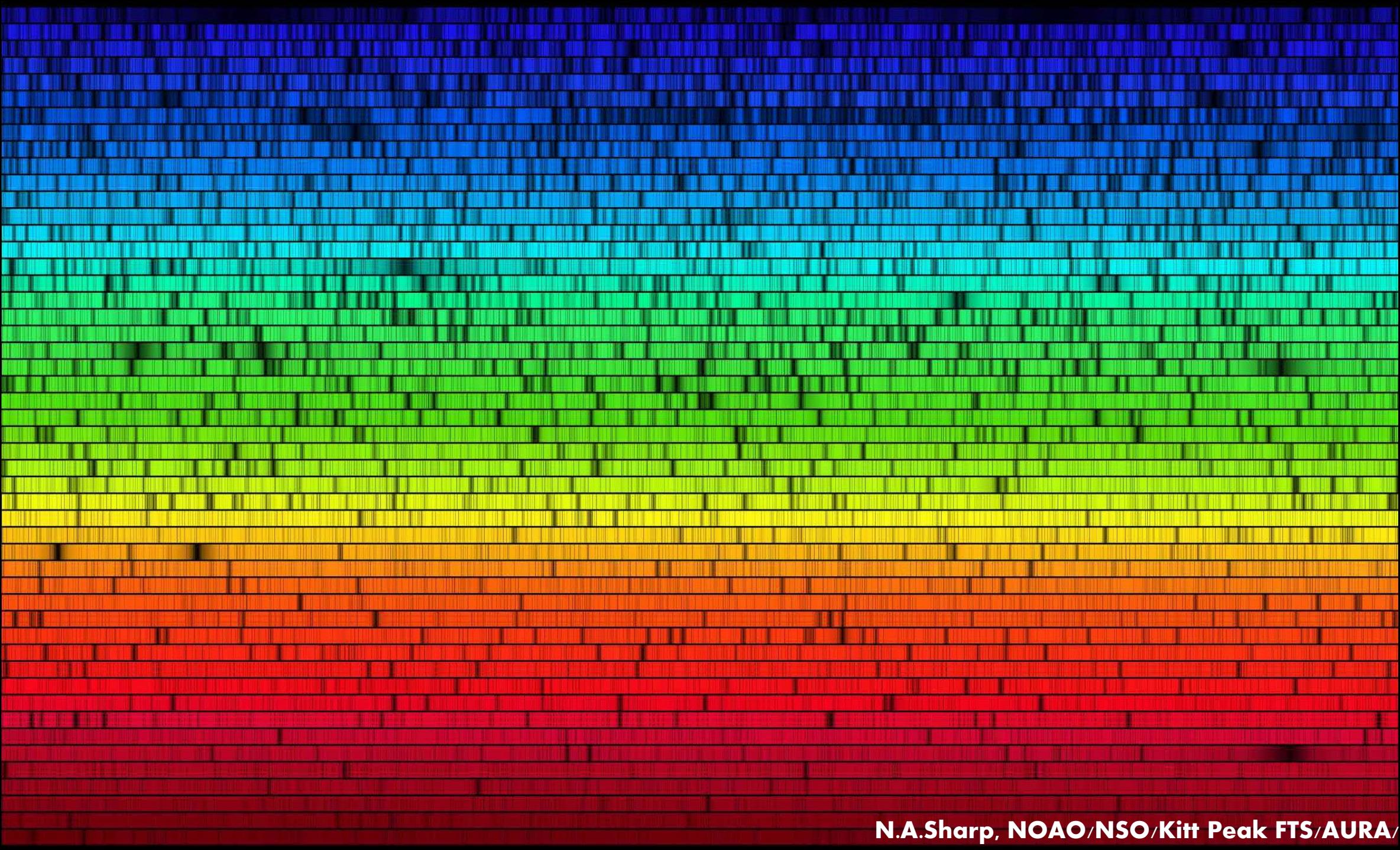
- Hydrogen
- Helium
- Lithium
- Sodium
- Mercury
- Neon

Eyeball view



Diffraction grating view





N.A.Sharp, NOAO/NSO/Kitt Peak FTS/AURA/NSF

# Recap



- 1. What is the difference between an absorption and emission spectrum?**
  
- 2. How do we get the spectra of stars?**
  
- 3. What does a hot object emit?**
  
- 4. Describe a perfect blackbody.**



# Spectral Type

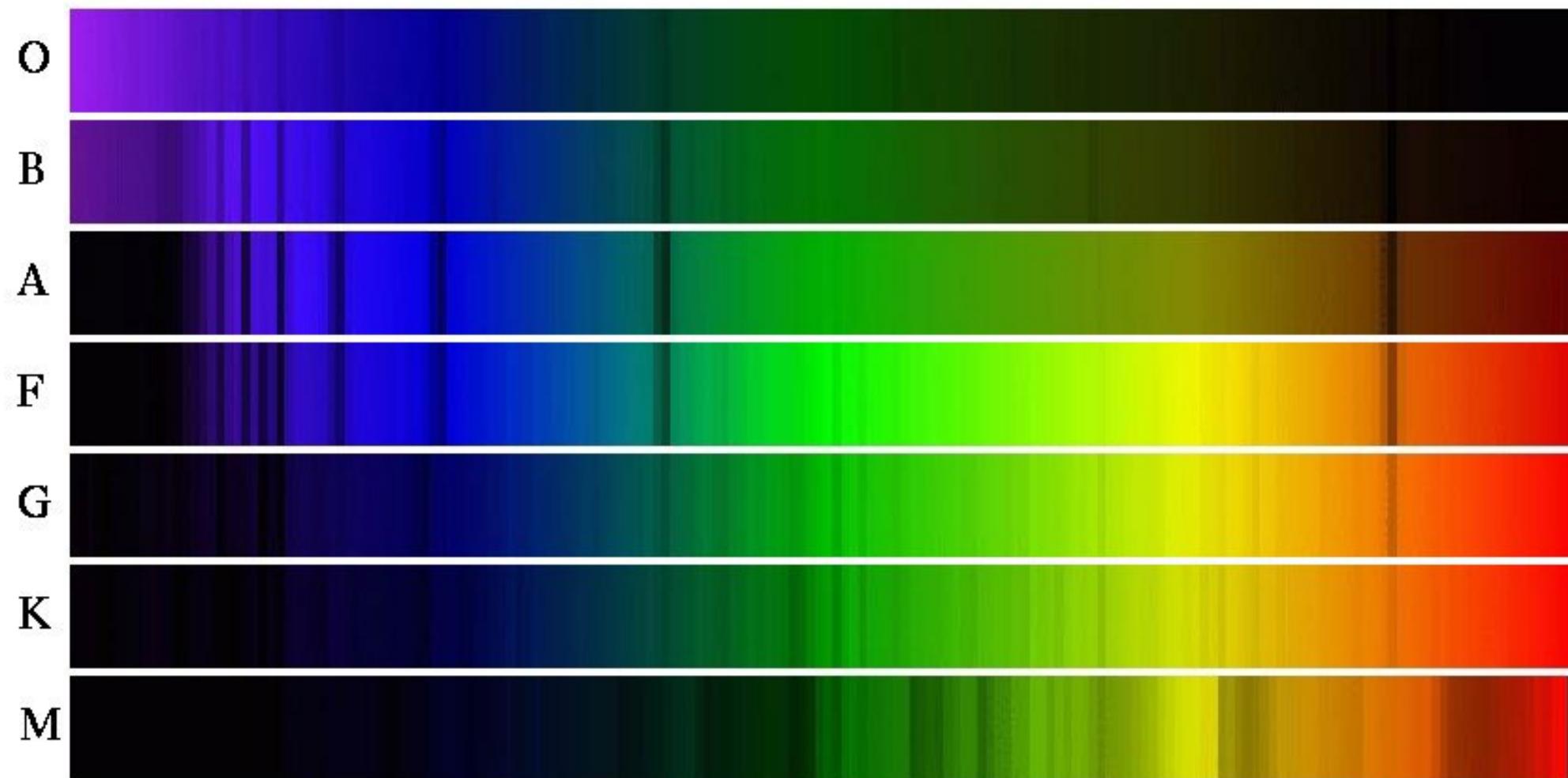
OBAFGKMLTY

Orion Battles across Far Galaxies Killing Martians

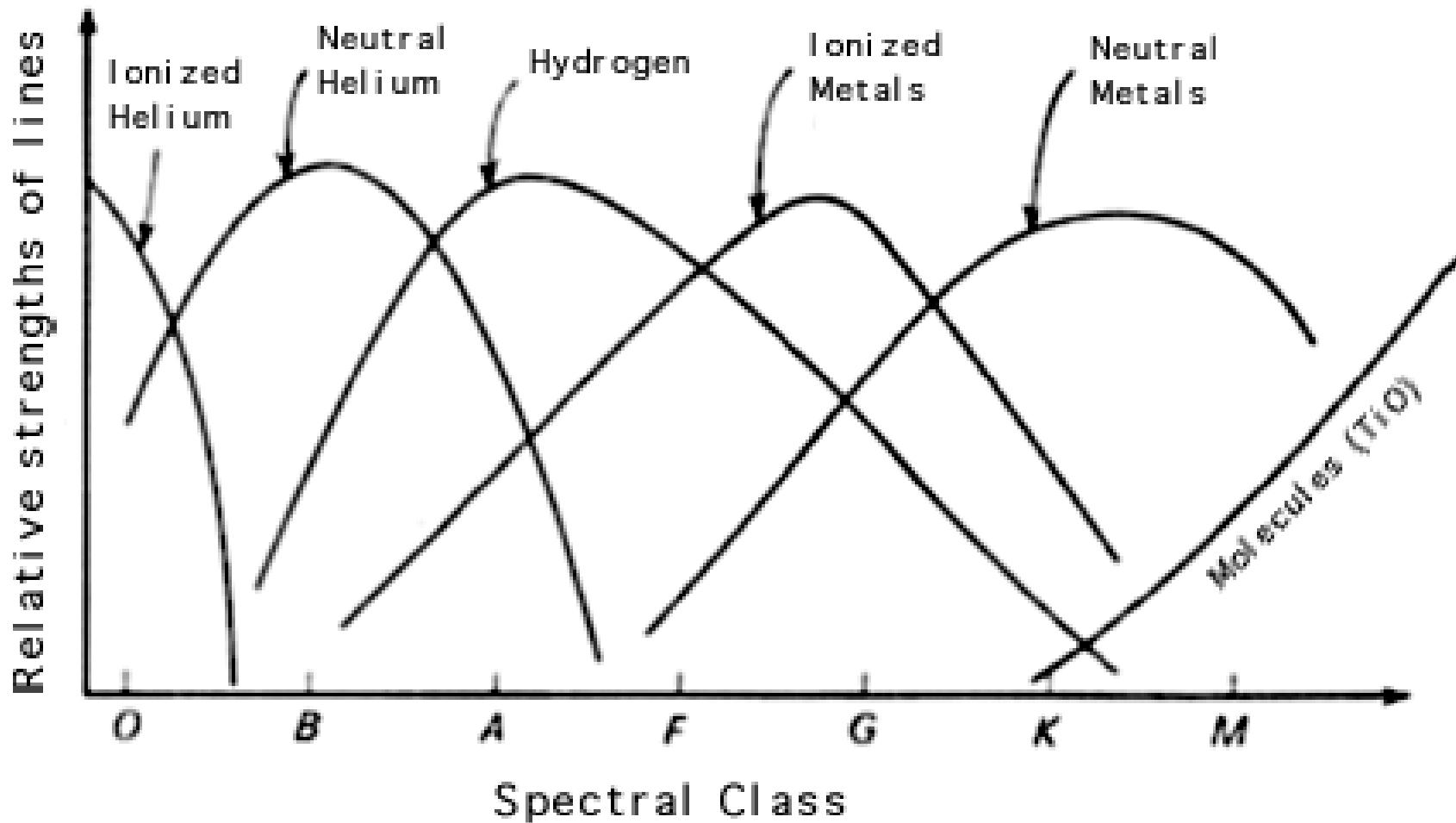
	Class	Temperature	Apparent color	Hydrogen lines	Other noted spectral features
O	O	$\geq 30,000$ K	blue	Weak	ionized helium lines
B	B	10,000–30,000 K	blue white	Medium	neutral helium
A	A	7,500–10,000 K	white to blue white	Strong	ionized calcium (weak)
F	F	6,000–7,500 K	white	Medium	ionized calcium (weak)
G	G	5,200–6,000 K	yellowish white	Weak	ionized calcium (medium)
K	K	3,700–5,200 K	yellow orange	Very weak	ionized calcium (strong)
M	M	$\leq 3,700$ K	orange red	Very weak	Titanium oxide lines

# Spectral Type

OBAFGKMLTY



# Spectral Type



# Luminosity

$$L = A\sigma T^4$$

Luminosity, L is measured in Watts (W). Think of it as the Power of the star.

A is the surface area of the star in m<sup>2</sup>

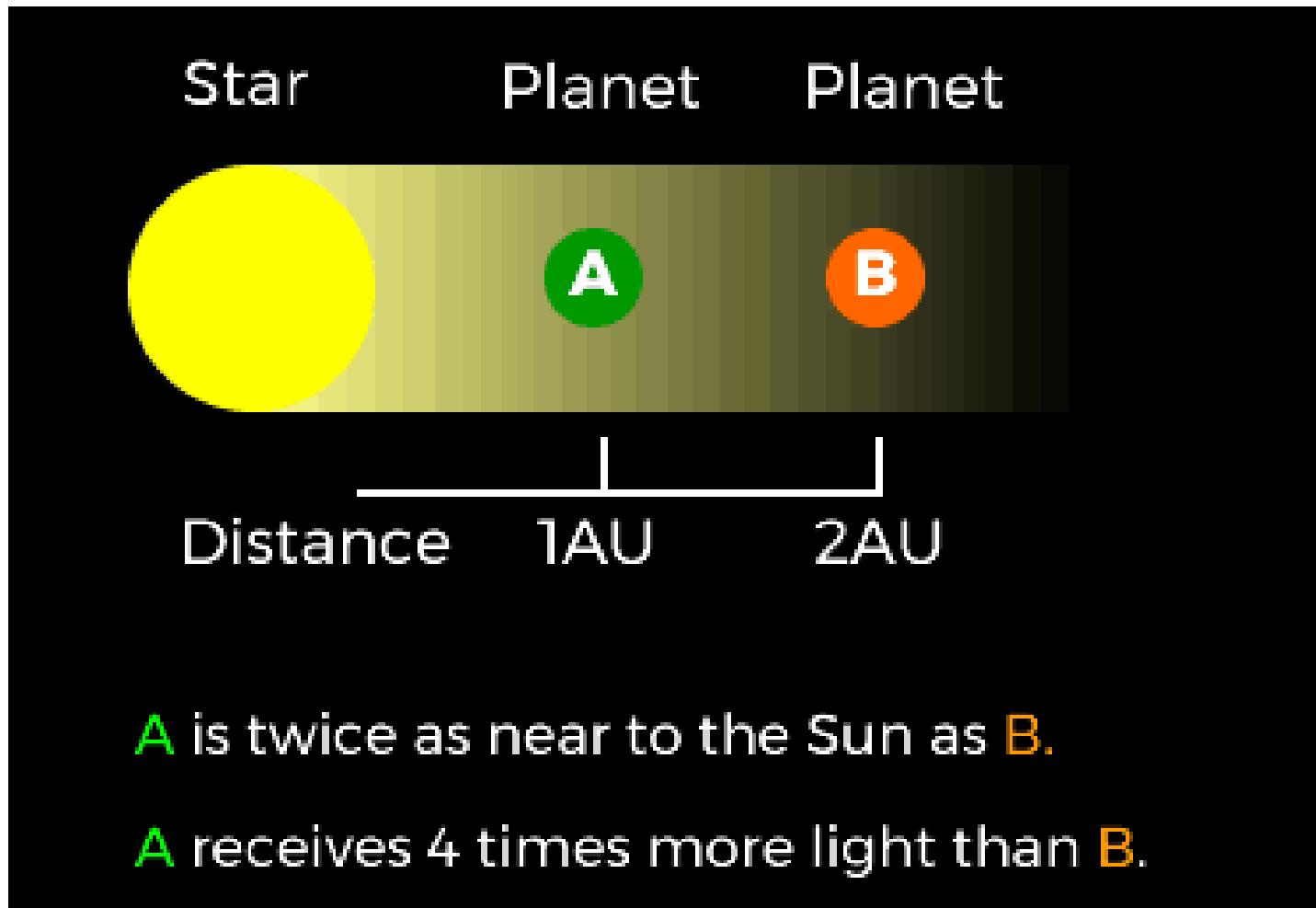
$\sigma$  is the Stefan-Boltzmann Constant, 5.67 Wm<sup>-2</sup>K<sup>-4</sup>

T is the temperature in Kelvin (K)

# Inverse-square law

The further away from a light emitting object the less light you receive.

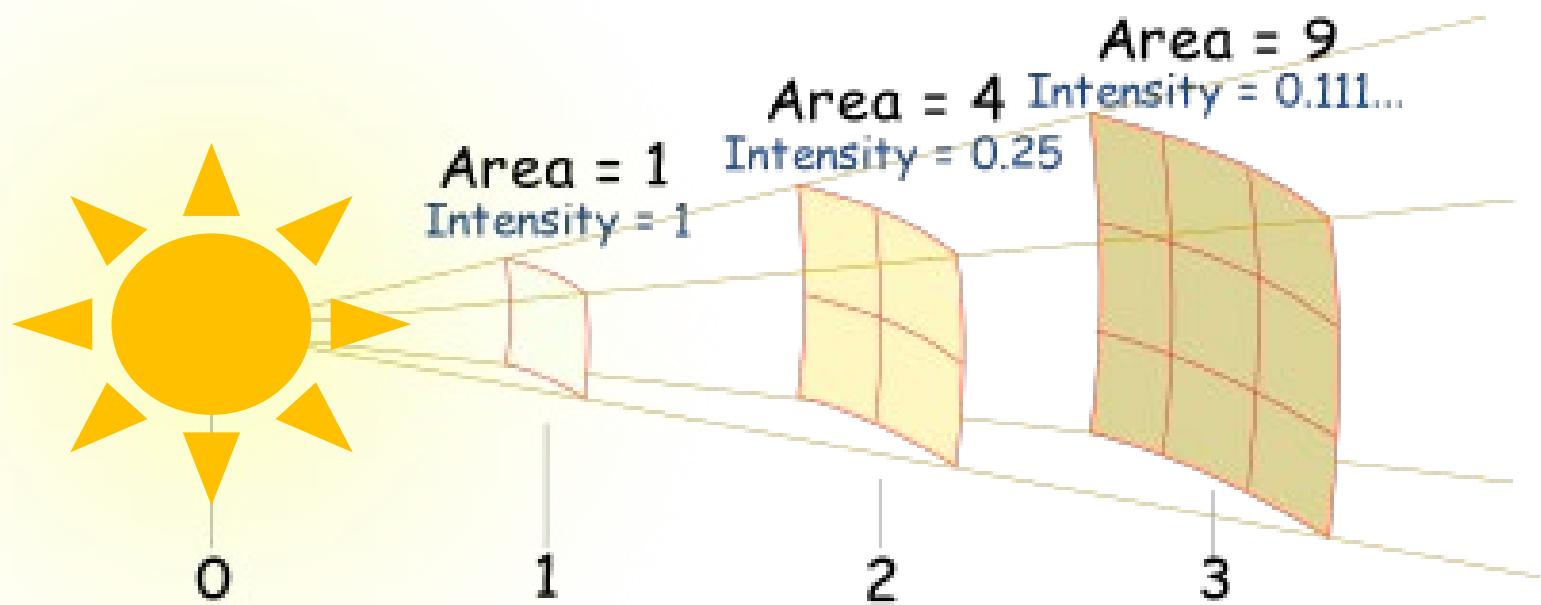
If you double the distance you receive four times less light.



# Inverse-square law

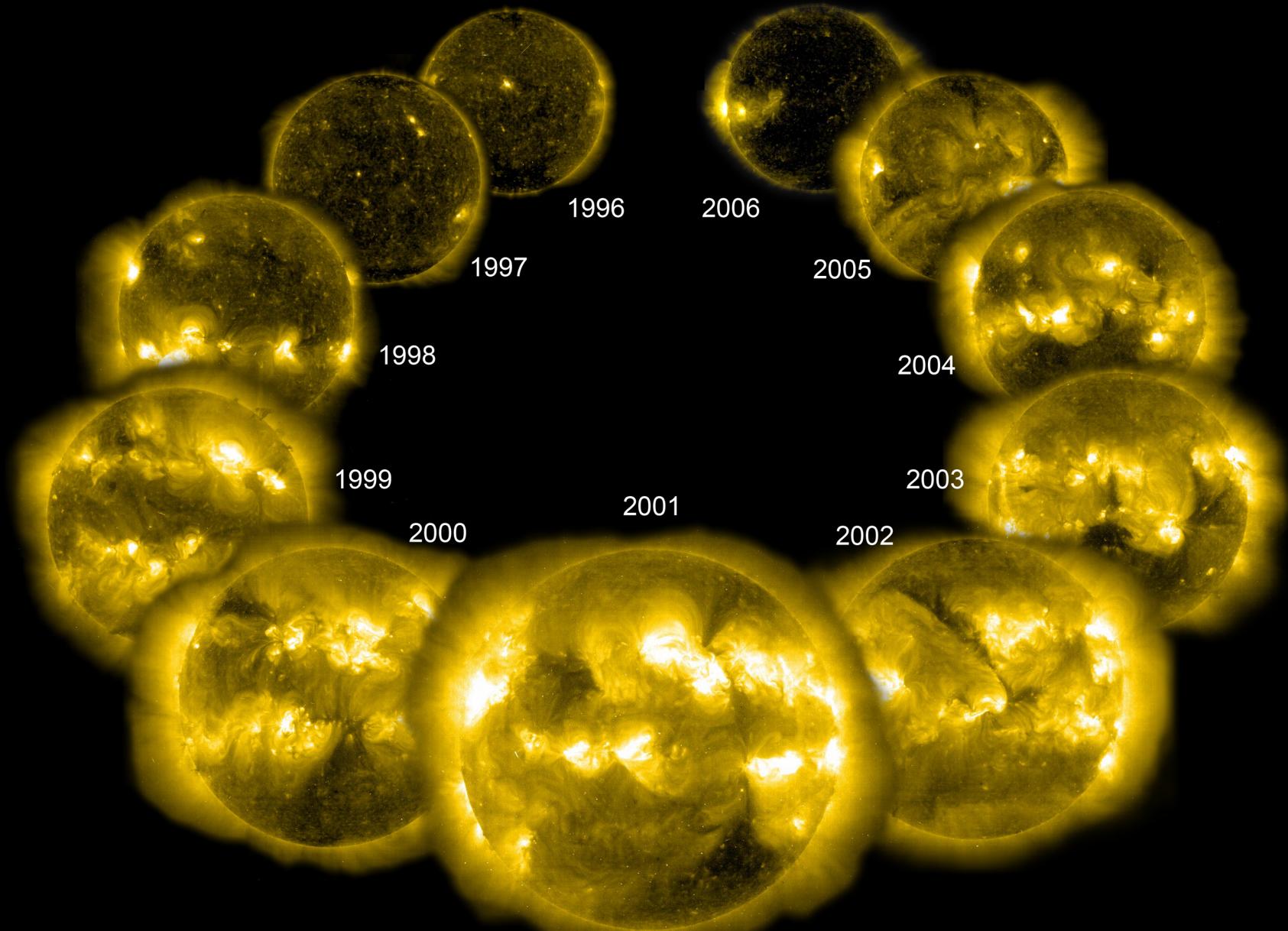
The brightness (intensity) of light is given by:

$$b = \frac{L}{4\pi d^2}$$



It has units of  $\text{Wm}^{-2}$ .

$d$  is the distance you are from the star.



# Recap



1. What are the spectral types in order?
2. What spectral type is our Sun?
3. Describe the inverse square law for light.
4. How has the luminosity of the Sun changed?





Up next:

# Nuclear Fusion

