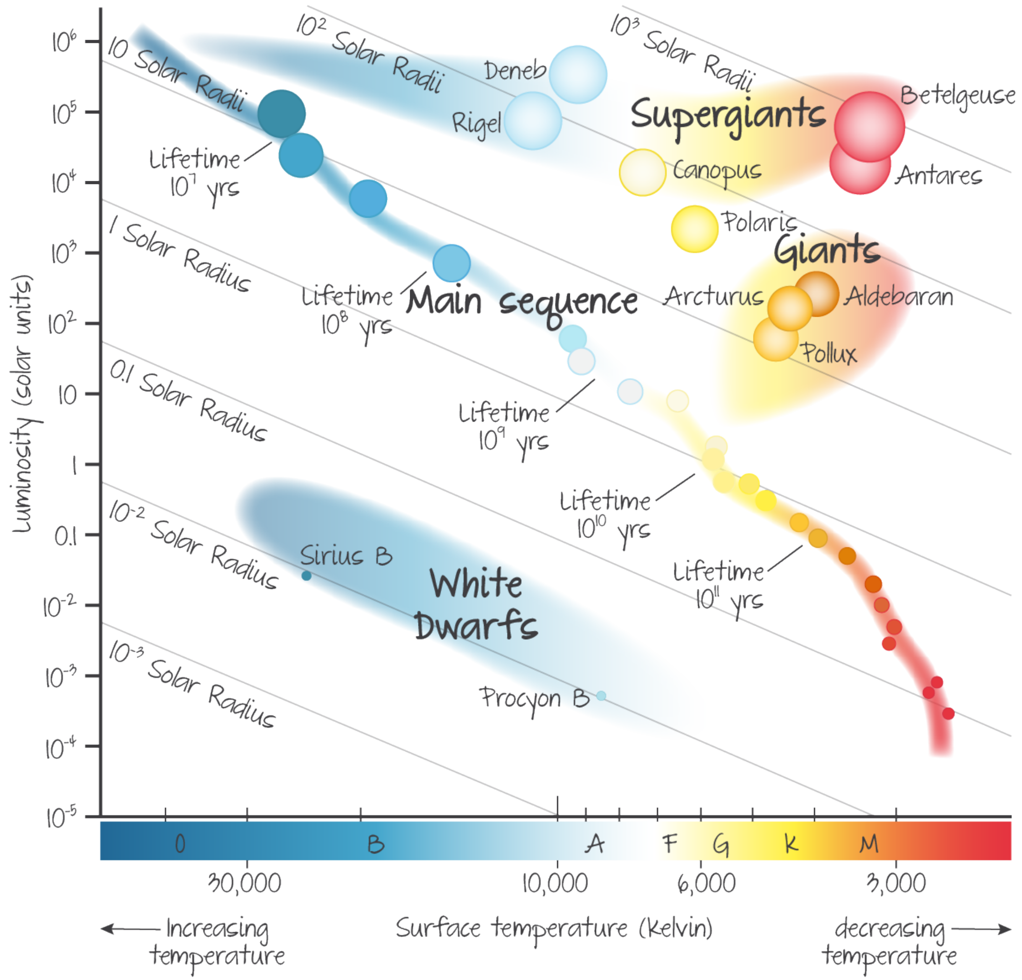
H-R Diagrams and Stellar Spectra

IB PHYSICS | ASTROPHYSICS

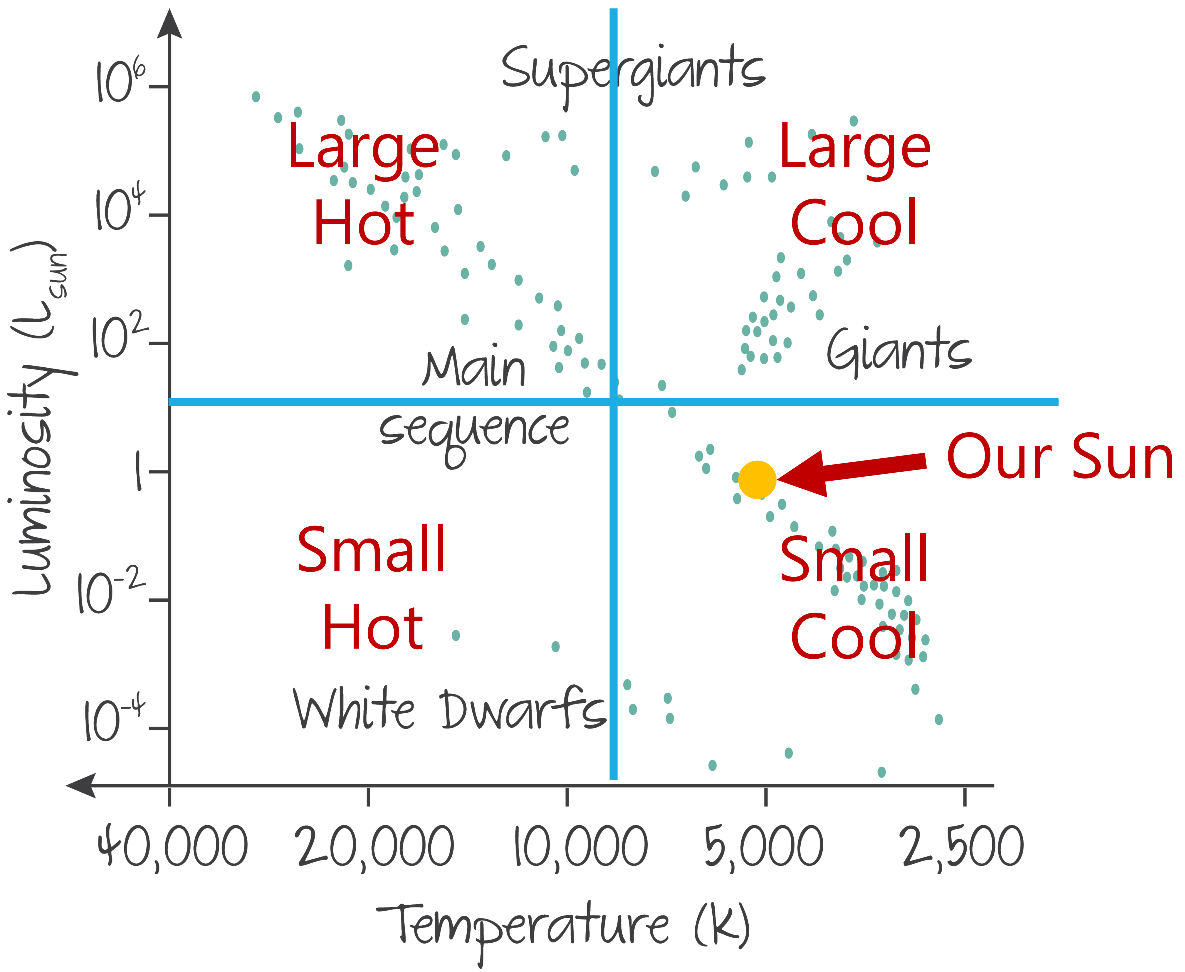
H-R Diagrams

L_{sun}

$L_{\odot}$



H-R Diagrams



Supergiants
Large
Hot
Large
Cool
Giants
Main sequence
Our Sun
Small
Hot
Small
Cool
White Dwarfs
Luminosity (L_{sun})
10^6
10^4
10^2
1
10^{-2}
10^{-4}
40,000
20,000
10,000
5,000
2,500
Temperature (K)

H-R Diagrams


Twinkle, twinkle, little star! How I wonder
where on the Hertzsprung-Russell diagram you are...

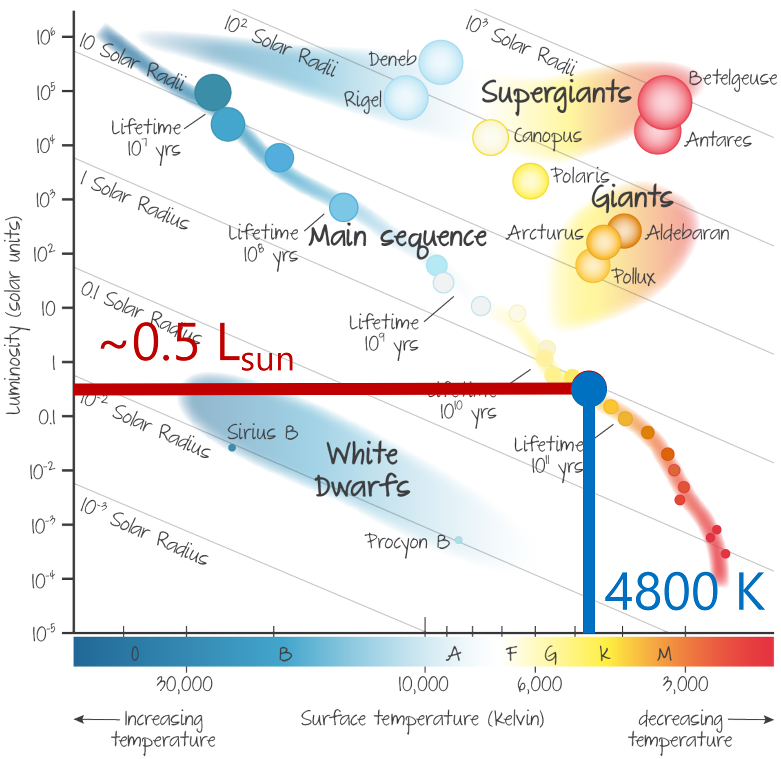
Sizes of Stars

IB Physics Data Booklet

Sub-topic D.1 – Stellar quantities	Sub-topic D.2 – Stellar characteristics and stellar evolution
$d\text{ (parsec)} = \frac{1}{p\text{ (arc-second)}}$ $L = \sigma A T^4$ $b = \frac{L}{4\pi d^2}$	$\lambda_{max} T = 2.9 \times 10^{-3}\text{ m K}$ $L \propto M^{3.5}$
Sub-topic D.3 – Cosmology	**Sub-topic D.5 – Further cosmology (HL only)**
$z = \frac{\Delta\lambda}{\lambda_0} \approx \frac{v}{c}$ $z = \frac{R}{R_0} - 1$ $v = H_0 d$ $T \approx \frac{1}{H_0}$	$v = \sqrt{\frac{4\pi G\rho}{3}} r$ $\rho_c = \frac{3H^2}{8\pi G}$

H-R Diagram for Calculating Distance

The maximum wavelength of a distant star is measured to be 600 nm, suggesting that it has a temperature of ~4800 K. If this star has a brightness of 1.0×10^{-12} W m^{-2}, what is its distance from Earth?



$L_{sun} = 3.84 \times 10^{24}$ W

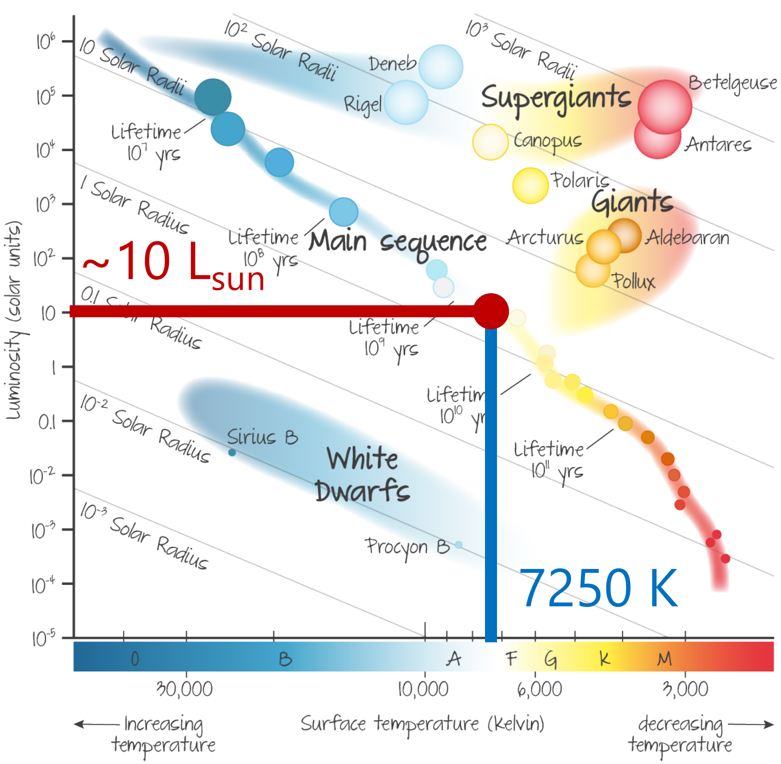
$$L_{star} = 0.5 \times (3.84 \times 10^{24})$$
$$= 1.92 \times 10^{24} \text{ W}$$

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

$$d = \sqrt{\frac{1.92 \times 10^{24}}{4\pi(1.0 \times 10^{-12})}} = \boxed{3.9 \times 10^{17} \text{ m}}$$

Try This

The maximum wavelength of a distant star is measured to be 400 nm. If this star has a brightness of 0.5×10^{-12} W m^{-2}, what is its distance from Earth?



$$L_{sun} = 3.84 \times 10^{24}\ \text{W}$$

$$T = \frac{2.90\times10^{-3}}{400\times10^{-9}}$$

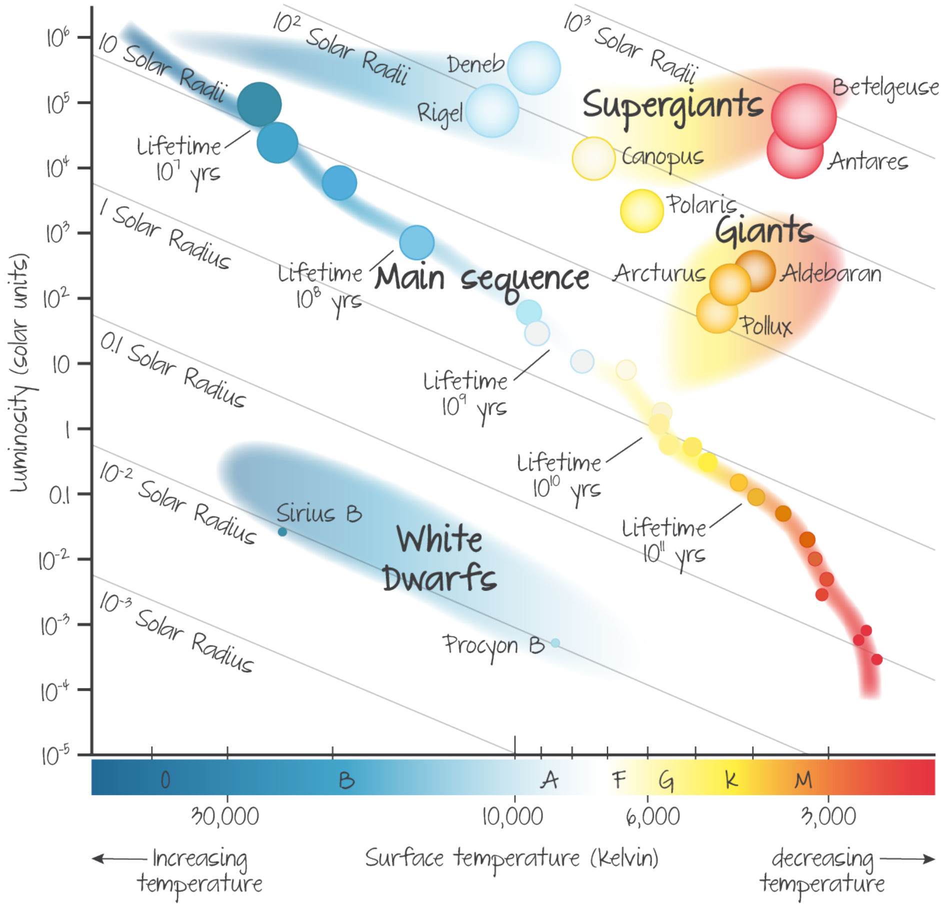
$$T = 7250\ \text{K}$$

$$L_{star} = 10\times(3.84\times10^{24})$$
$$= 3.84\times10^{25}\ \text{W}$$

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

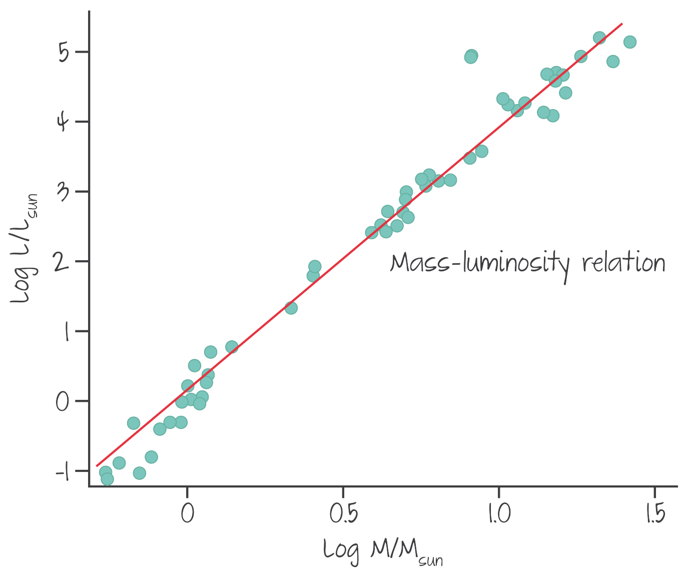
$$d = \sqrt{\frac{3.84\times10^{25}}{4\pi(0.5\times10^{-12})}} = \boxed{2.47\times10^{18}\ \text{m}}$$

Mass-Luminosity Relationship



For stars on the main sequence, there is a relationship between luminosity and mass

$$L \propto M^{3.5}$$



IB Physics Data Booklet

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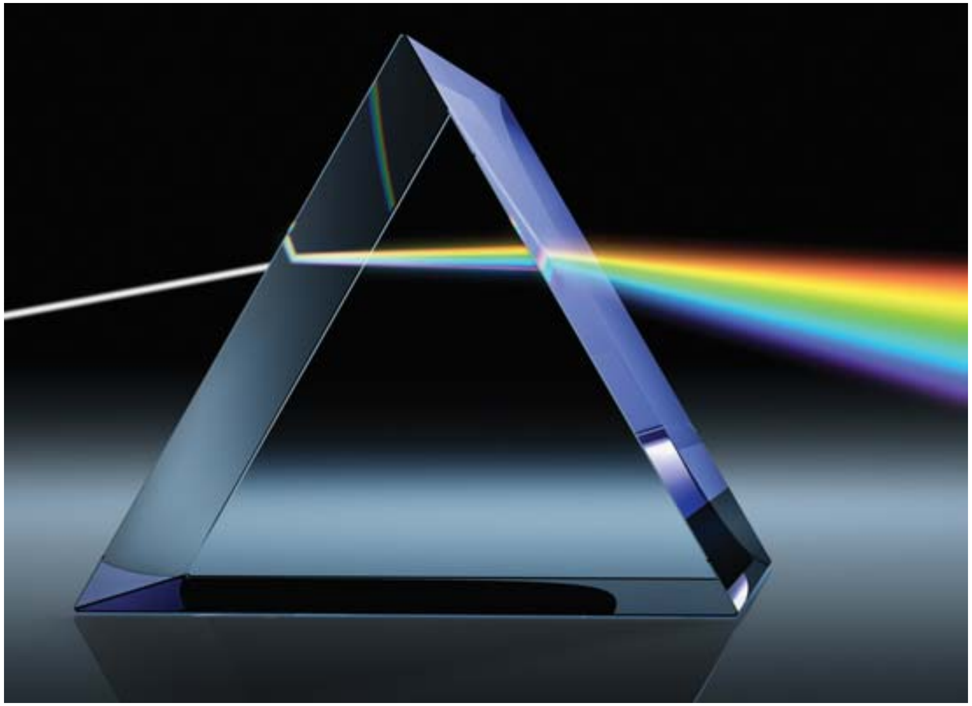
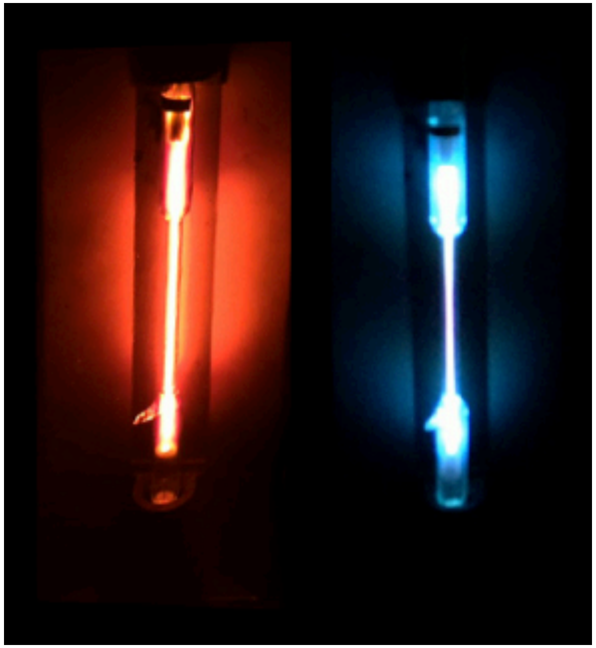
Continuous Spectrum

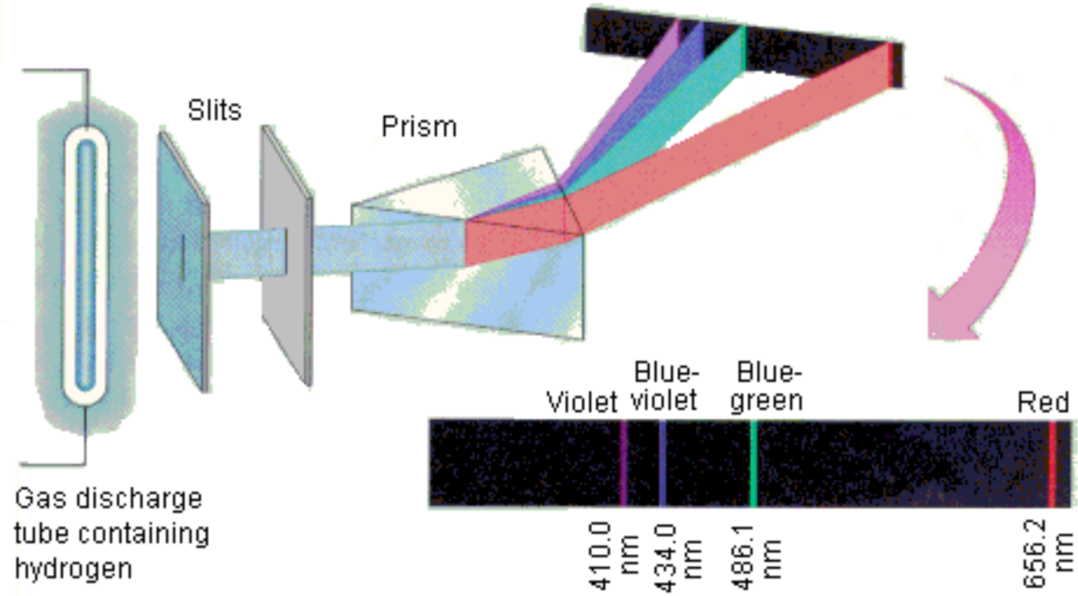
When white light from the sun passes through a prism, the light is dispersed into its component colors in a continuous spectrum



Emission Spectrum

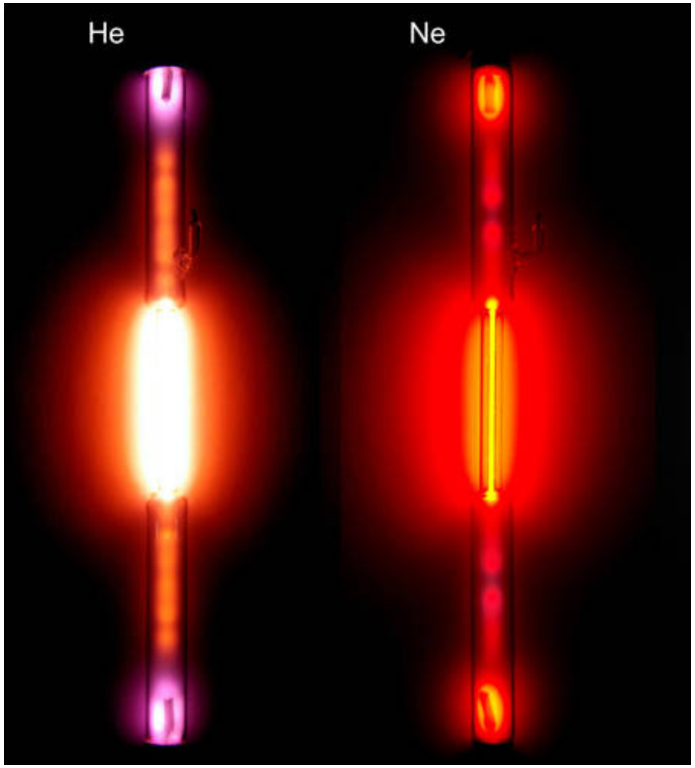
If an electric current is passed through an element in the form of a low-pressure gas, it will produce its own unique emission spectrum

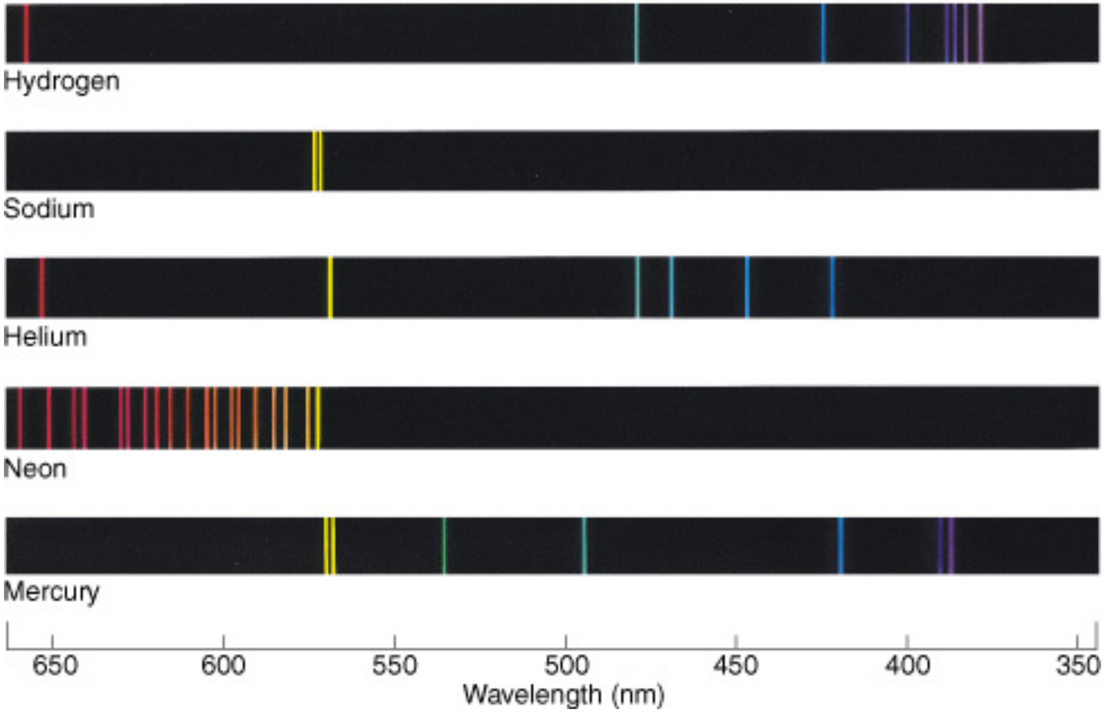




Emission Spectrum

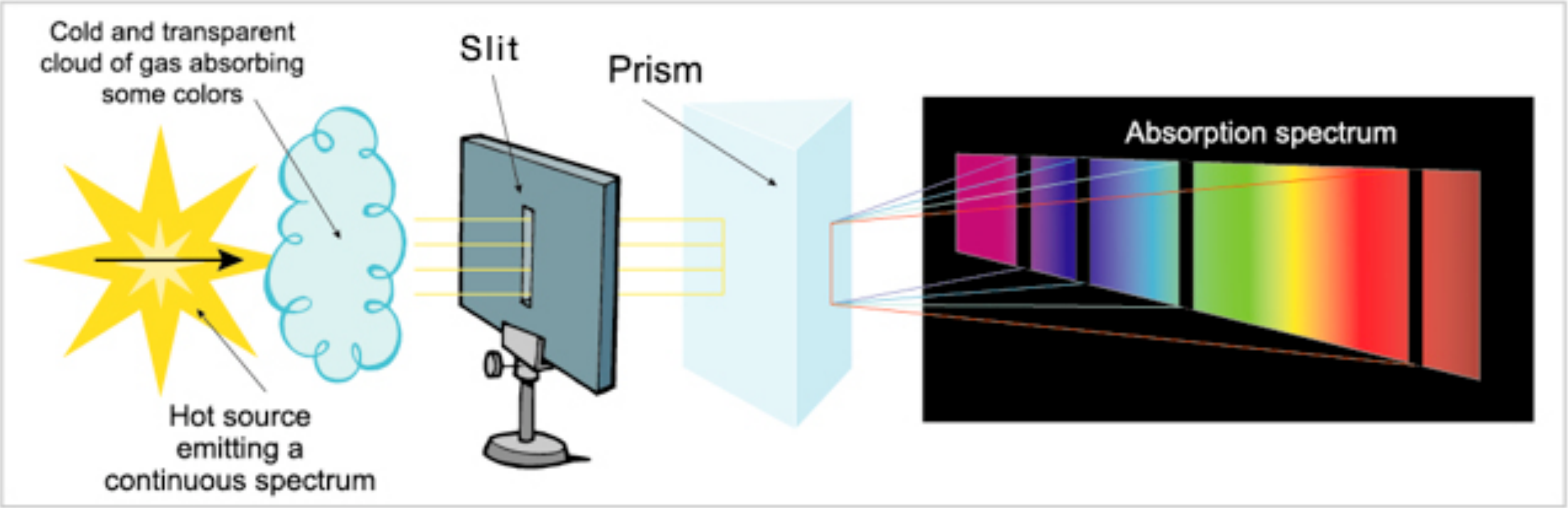
These spectra can be used to identify elements like a fingerprint



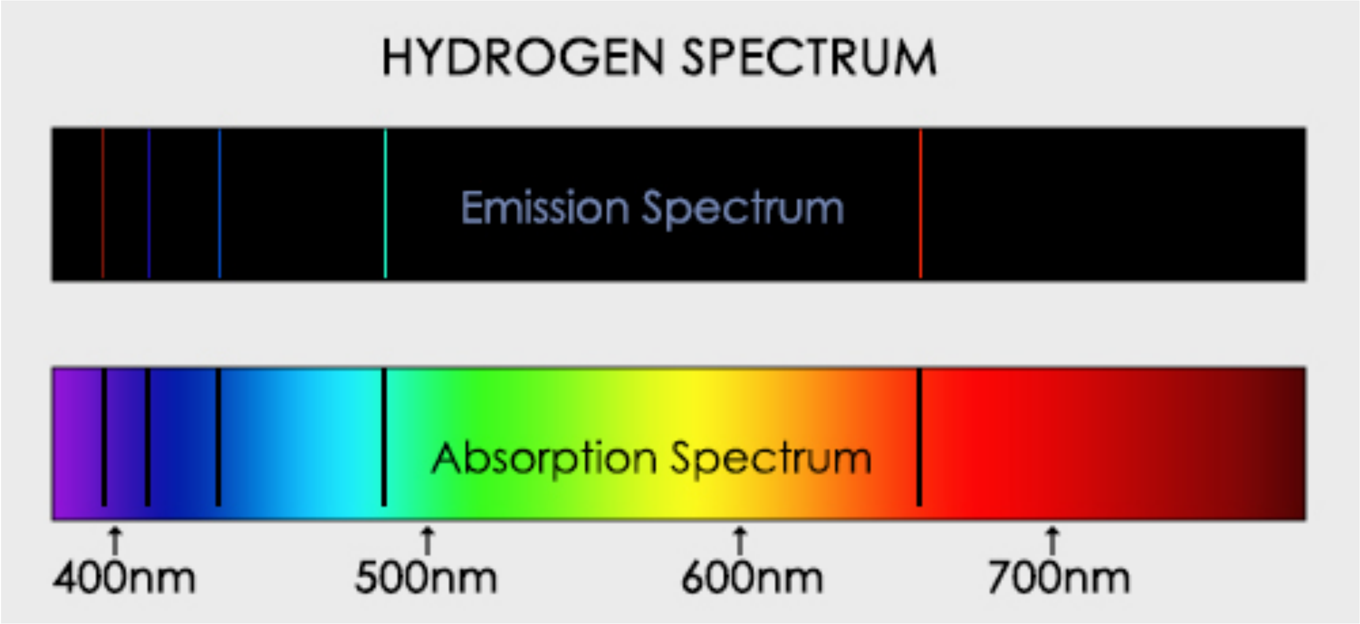


Absorption Spectrum

If white light is passed through a sample of gaseous atoms or molecules, it is found that the light of certain wavelengths is missing

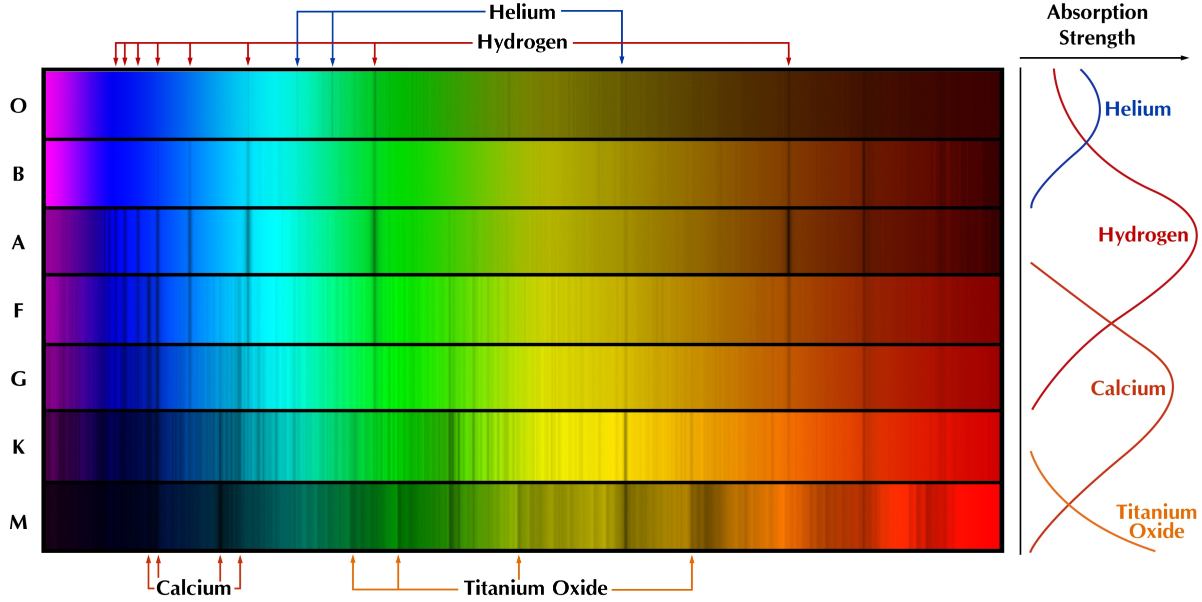


Absorption Spectrum



Stellar Spectra

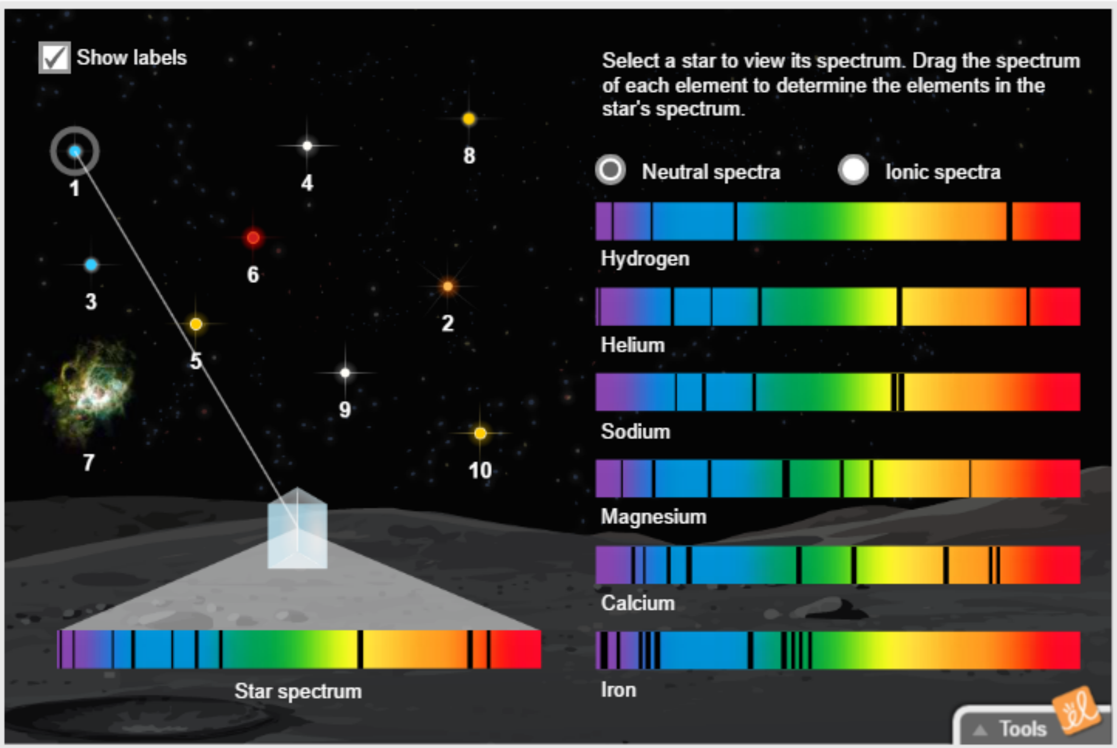
Studying the Spectra of Stars can help determine what the stars are made of



Are these **Emission Spectra** or Absorption Spectra?

Stellar Spectra | Try it out

Compare the spectra of the stars with the known absorption spectra of different elements to determine the composition of the stars



N → Neutral Spectra   I → Ionic Spectra

1	2	3	4	5	6	7	8	9	10
N		N	N	N		N		N	
N		I				N			
			I	N		N		N	N
	N								
	N		I		N		N		I
	N				N		I		

↑ Redshifted