Make sure to pick up a grating from Emily!

You need to give them back after class.

Astronomy 122

This Class (Lecture 11):

Twinkle, Twinkle, Little Star

Next Class:

Stellar Evolution:
The Main Sequence

Music: *Starlight* – Muse

HW

- Last Wednesday was good. More than 33% of students looked at the HW-short before discussion section.
- Keep it up this week…
- Don't make me sad….

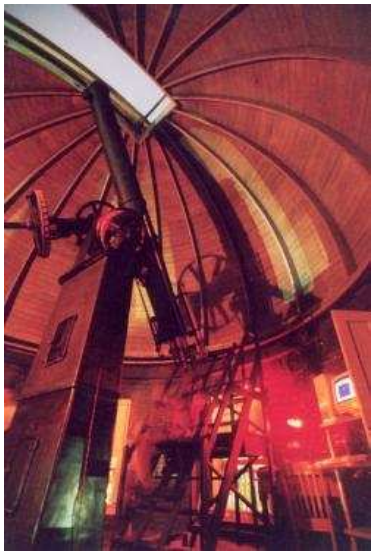
Lunar Eclipse

- Lunar Eclipse on Wednesday night!
- Shadow of Earth on Full Moon.
  - Enter the penumbra at 1840
  - Enter the umbra at 1943
  - Enter totality at 2100
  - Exit totality at 2150
  - Exit umbra 2309
  - Exit penumbra at 0016

http://spacsun.rice.edu/~has/images/RB_Lunar-Eclipse-Phases-Center_10_29.jpg

Night Observing

- Night observing started!
  - Feb 20th: Wednesday (special Lunar Eclipse!)
  - Feb 25-28th: Monday-Thursday
- Don't wait until last minute (never know about Illinois weather)!
- Observing sessions are from 7:30pm-9:30pm (allow 45 mins to complete)

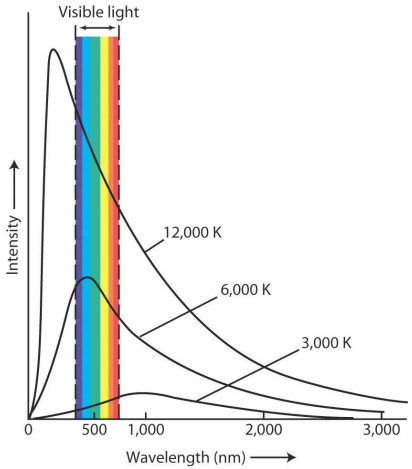


Outline

- Brightness
  - The Sun shines out of your eyes
- Magnitudes
- Lines!.. Lines!.. Spectral lines I say!

The Spectrum of Blackbody Radiation

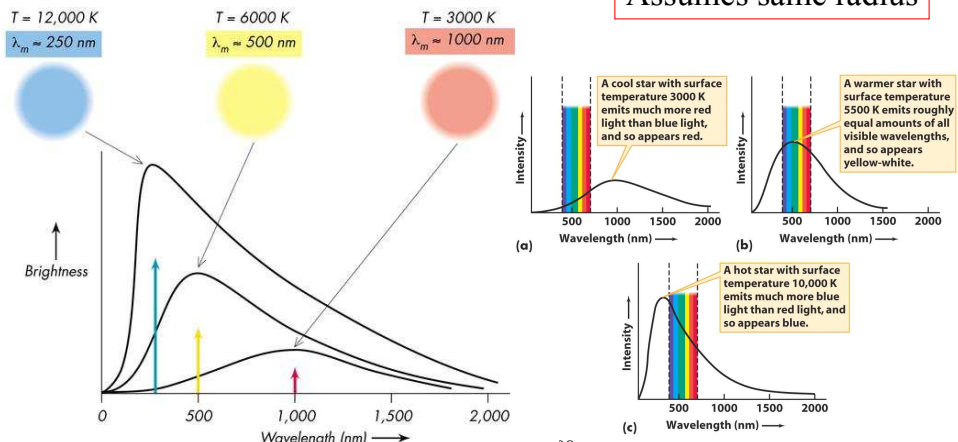
- For higher temperature the maximum occurs at shorter wavelengths.
- For lower temperatures the maximum occurs at longer wavelengths.



Stellar Colors

- Higher temperature → brighter, bluer
- Lower temperature → dimmer, redder

Assumes same radius



Color me..

White hot Sirius to a red supergiant Betelgeuse

Which is Brighter?

a) Moon
b) Streetlamp

- Why?
- *Apparent brightness* and *luminosity* difference.

http://www.danheller.com/images/California/CalCoast/SantaCruz/Slideshow/img13.html

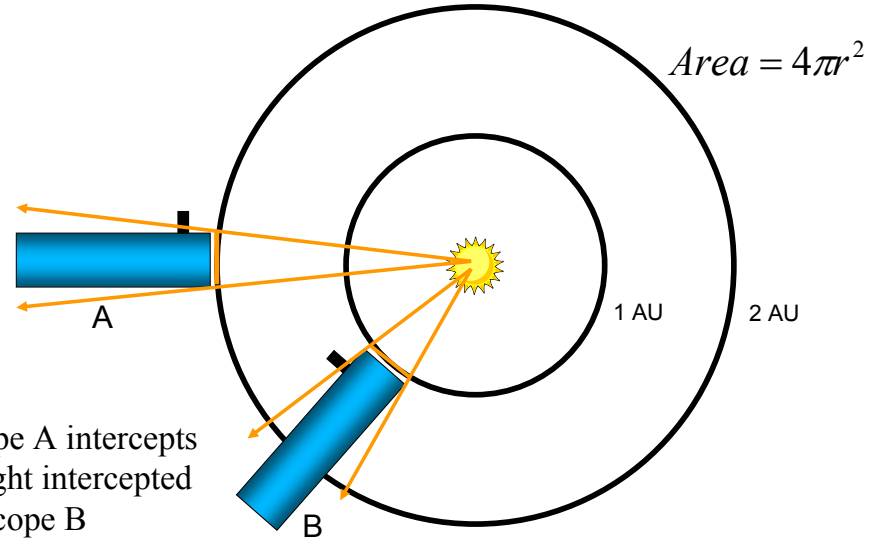
Which is Brighter?

- Apparent brightness (flux) will depend on distance, but…
- Luminosity measures how much energy object emits per second, which is independent on distance.

http://www.danheller.com/images/California/CalCoast/SantaCruz/Slideshow/img13.html

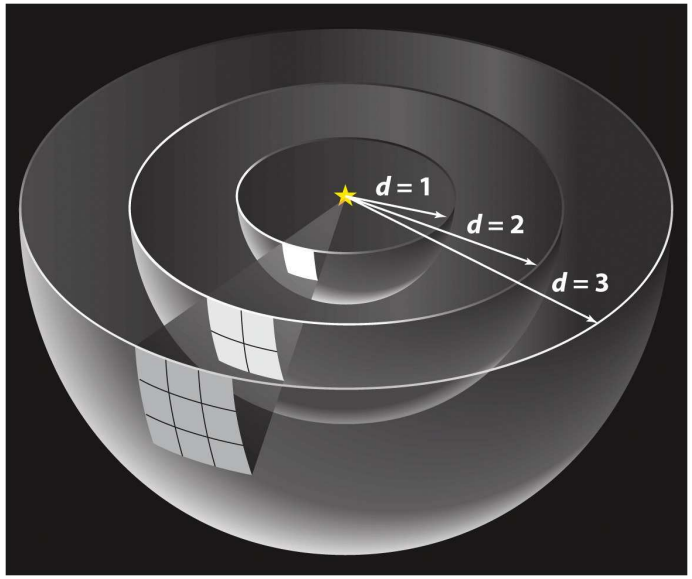
Why do more distant objects look so much fainter?

- More distant stars of a given luminosity appear dimmer
- Apparent brightness drops as square of distance



Telescope A intercepts ¼ the light intercepted by telescope B

Same number of Photons, but more area.

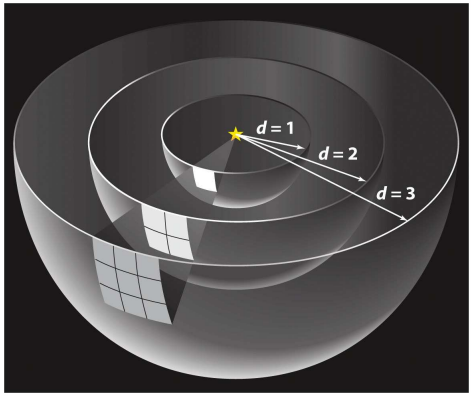


Luminosity

- Apparent brightness ≠ luminosity!
- Apparent brightness depends on distance away.

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

- The farther, the dimmer.
- That's why it's called apparent brightness.



Apparent Brightness

If you visited Pluto how would the apparent brightness of the Sun change? Pluto is 40 times farther away than Earth.

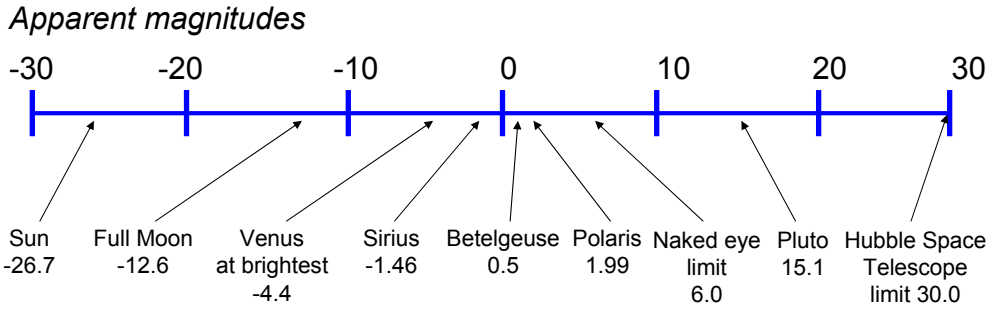
a) 1600 times brighter
b) 1600 times dimmer
c) 40 times brighter
d) 40 times dimmer
e) The same

Measuring Star Brightness

In 130 BC, a Greek astronomer, Hipparchus, classified all the stars visible to the naked eye into 6 **magnitudes**

- 1st magnitude – the brightest stars visible
- 21 "1st magnitude stars"
- 6th magnitude – the dimmest stars visible
- For magnitudes, a smaller number is brighter (sorry about that), or more negative.
- There are more dimmer stars than bright stars

Apparent Magnitude Scale



The human eye sees in a sort of logarithmic (powers) way. Each magnitude is 2.512 times brighter.

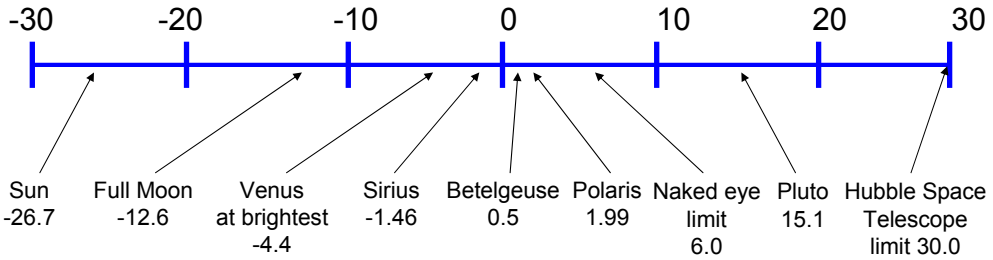
Note: apparent magnitude is really flux (intensity) as it is related to luminosity and distance

Apparent Magnitudes

$$F_A / F_B = 2.512^{(m_B - m_A)}$$

- Vega is nearly zero magnitude
- A star that is 5 magnitudes **bigger** than Vega, would be 100 times **less** bright
- Each magnitude is 2.512 times brighter than the next magnitude **down**
  - 2.512 x 2.512 x 2.512 x 2.512 x 2.512 = 100

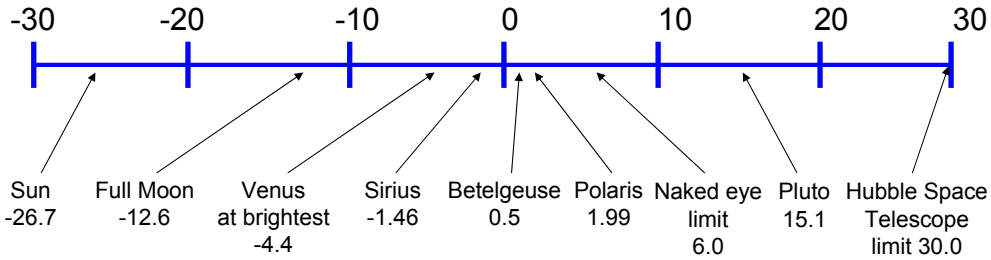
Apparent Magnitude Scale



How much dimmer is Sirius, compared to the Sun?

$$F_{Sirius} / F_{Sun} = 2.512^{(m_{Sun} - m_{Sirius})}$$

Apparent Magnitude Scale



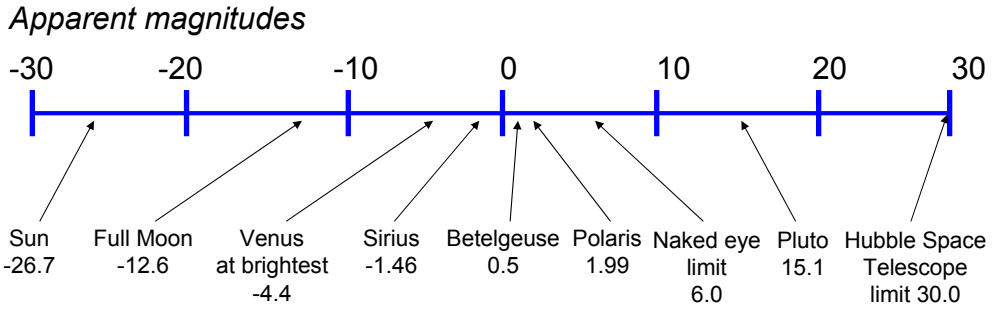
How much dimmer is Sirius, compared to the Sun?

$$F_{Sirius} / F_{Sun} = 2.512^{(m_{Sun} - m_{Sirius})}$$

$$m_{Sun} = -26.7 \text{ and } m_{Sirius} = -1.46$$

$$\Rightarrow m_{Sun} - m_{Sirius} = -25.24$$

Apparent Magnitude Scale



How much dimmer is Sirius, compared to the Sun?

$$F_{Sirius} / F_{Sun} = 2.512^{(m_{Sun} - m_{Sirius})}$$

$$\Rightarrow \frac{F_{Sirius}}{F_{Sun}} = 2.512^{-25.24} = 8 \times 10^{-11}$$

Absolute Magnitudes

- But apparent magnitudes are not very useful.
- To compare star brightness independently of distance, astronomers use **absolute magnitudes**
  - Equal to what the apparent magnitude would be if the star were 10 parsecs away
- This relates Luminosity!
- Then, we can say which star is really brighter.

Absolute Magnitudes

- To compare star brightness independently of distance, astronomers use **absolute magnitudes (M)**
  - Equal to what the apparent magnitude (m) would be if the star were 10 parsecs away

$$m - M = -5 + 5\log(d)$$

In these formulae d is in parsecs only!

$$d = 10^{(m-M+5)/5}$$

Absolute Magnitudes

- An example
  - The star Vega has an apparent magnitude of m=0.03
  - It is 7.5 parsecs away
  - Its absolute magnitude is therefore 0.65

$$m - M = -5 + 5\log(d)$$

Absolute Magnitudes

- An example
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$$M = m + 5 - 5\log(d)$$

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$m - M = -5 + 5\log(d)$

$M = m + 5 - 5\log(d)$

$$M = 0.03 + 5 - 5\log(7.5)$$

$$M = 0.65$$

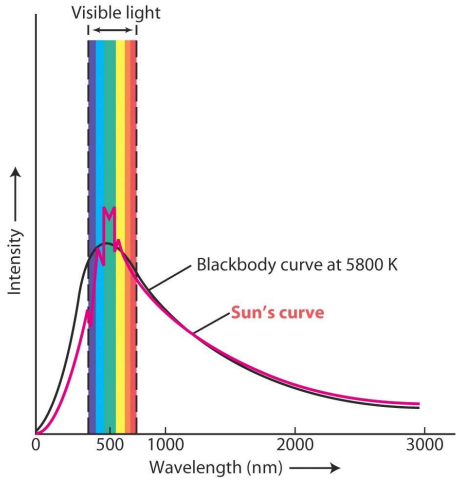
Absolute Magnitude

If you visited Pluto how would the absolute magnitude of the Sun change? Pluto is 40 times farther away than Earth.

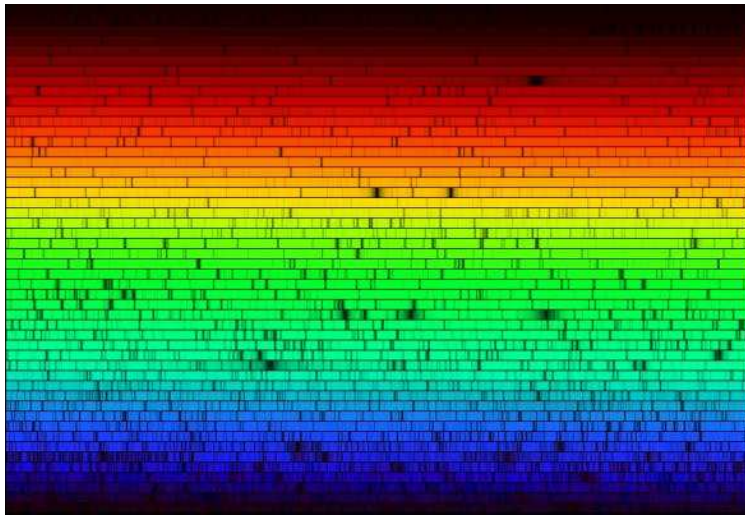
a) 1600 times brighter
b) 1600 times dimmer
c) 40 times brighter
d) 40 times dimmer
e) The same

The Sun's Color

Very close to a black body, but with some features.



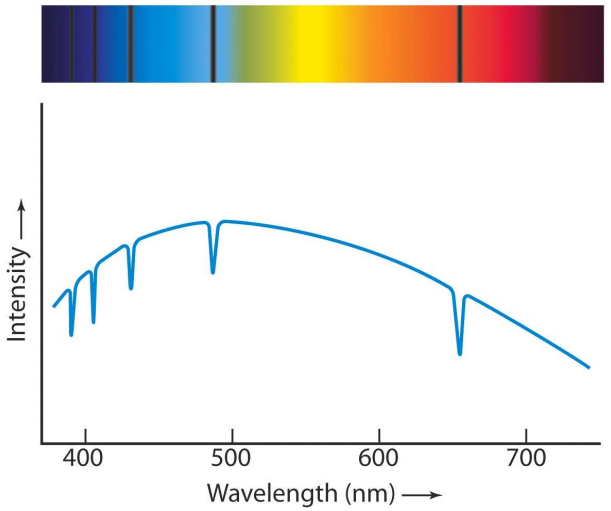
What Color is Sunlight?



http://antwrp.gsfc.nasa.gov/apod/ap000815.html

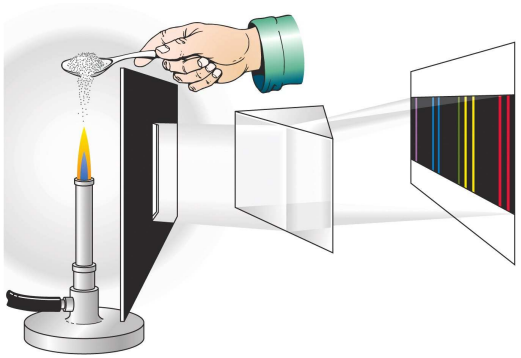
Spectrum Lines

- When astronomers looked at the spectra of the Sun and stars, they saw **gaps**
- Not a perfect blackbody spectrum!
- Called *dark spectrum lines*



In the Laboratory

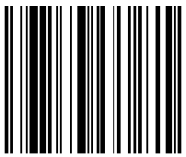
- Bright spectrum lines were produced and studied in the laboratory in the mid-1800s



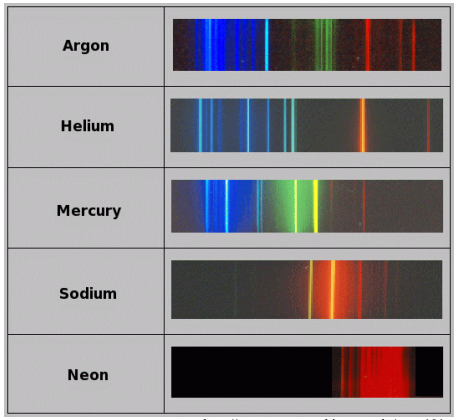
- Discovered that burning different chemical elements produced different patterns of lines

Spectrum Lines = Fingerprints

The pattern of spectrum lines produced by a gas depends on its chemical composition



Or a barcode!



http://www.astro.washington.edu/astro101v

Question

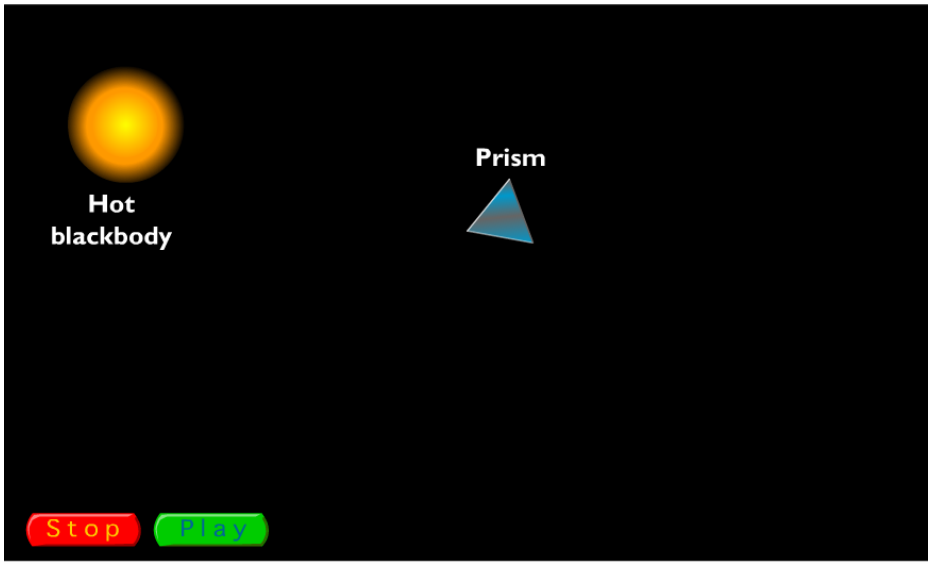
What is the mystery element?

a) Hydrogen
b) Neon
c) Helium
d) Nitrogen
e) Blackbody

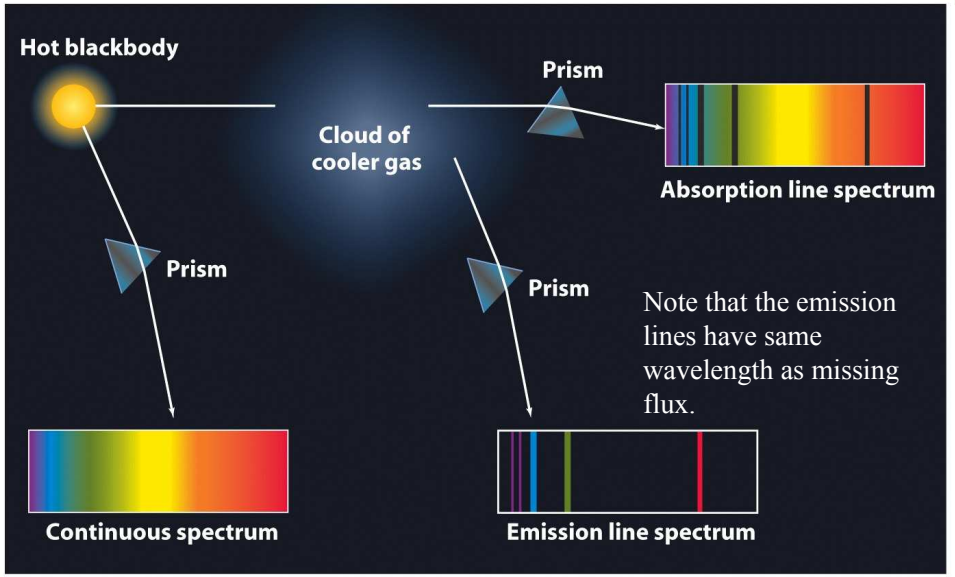
Kirchoff's Laws

- Law 1: A hot opaque body, such as a blackbody or a hot dense gas, produces a continuous spectrum– a rainbow of colors.
- Law 2: A hot transparent gas will produces emission line spectrum– a series of bright spectral lines with a dark background.
- Law 3: A cool, transparent gas in front of a blackbody, produces an absorption line spectrum– it removes the light at the same colors as the gas would emit if it was hot (from Law #2)

Kirchoff's Laws



Kirchoff's Laws



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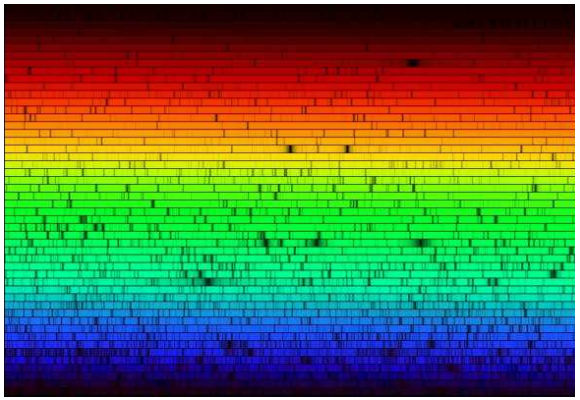
Solar Spectrum Lines



- The Sun shows dark spectrum lines
- Upper part of the photosphere is cooler than the lower part
- Cooler gas around a continuous spectrum source
- Therefore, we get an absorption spectrum!

Solar Composition

- From the spectra lines, we can determine the Sun's composition
  - 92% Hydrogen
  - 8% Helium
  - Less than 0.1% other stuff