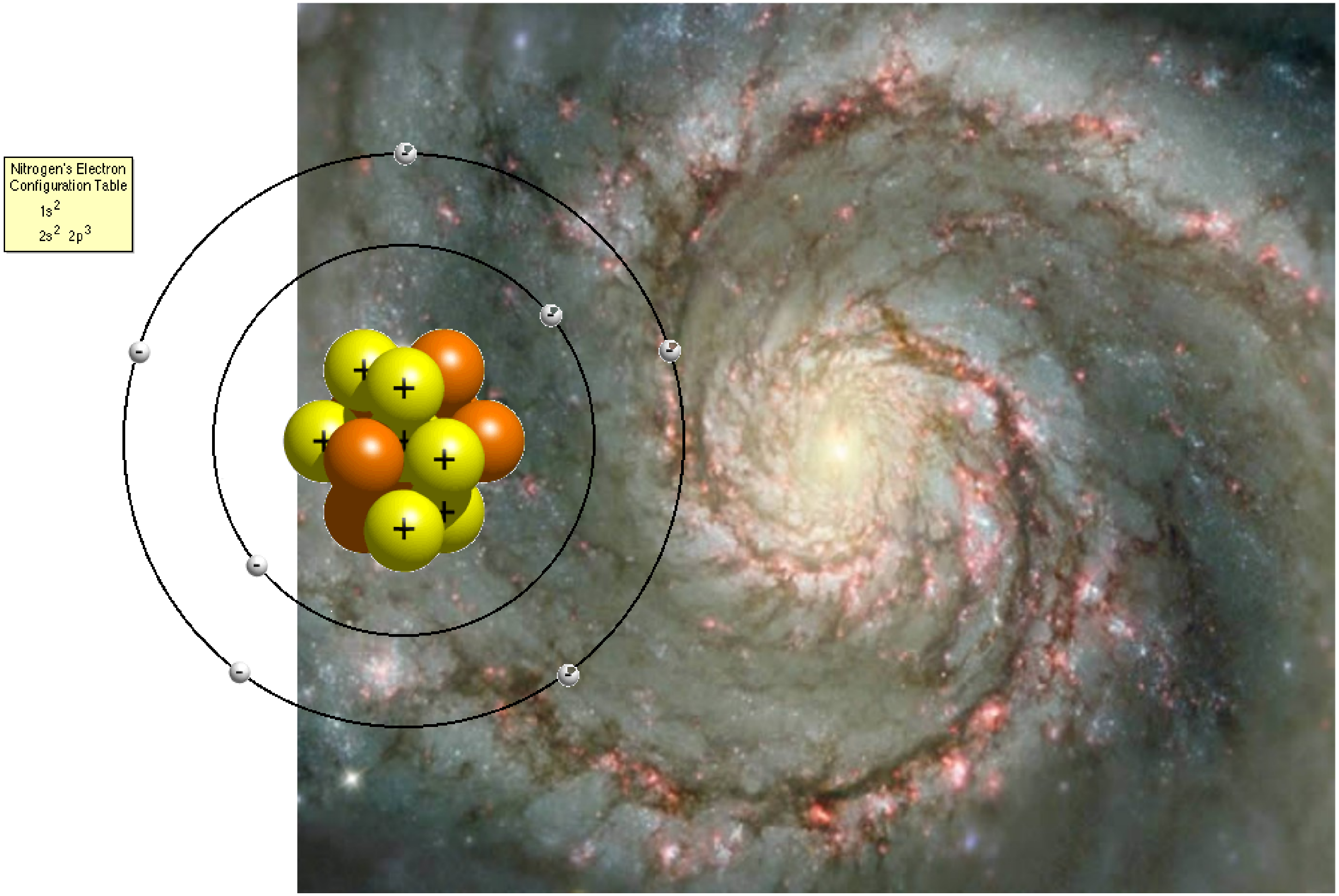
ATOMIC SPECTRA and FINGER PRINTS OF ATOMS

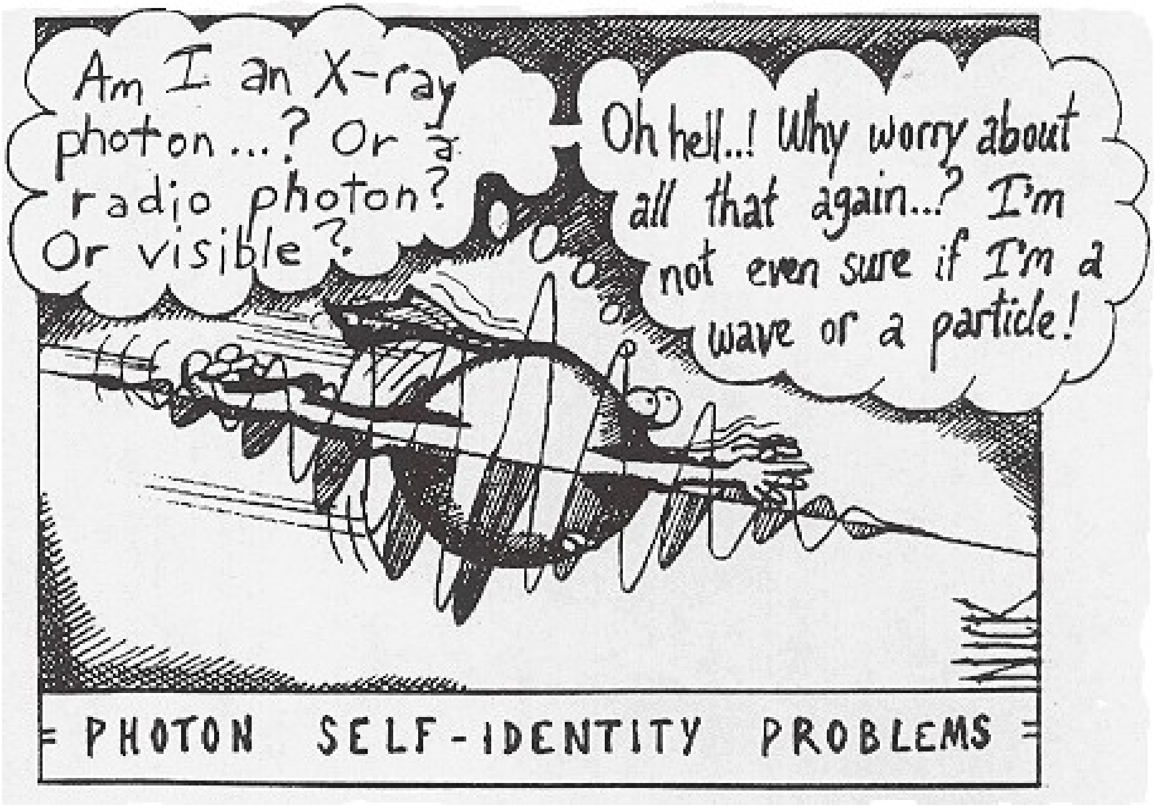
The Bohr Model

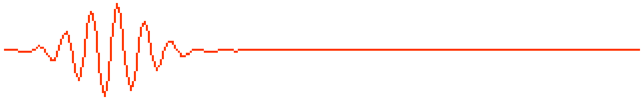
http://cas.sdss.org/dr7/en/proj/basic/spectraltypes/absorption.asp



Nature of light :

What is light ? a wave or a particle ? Or both ?

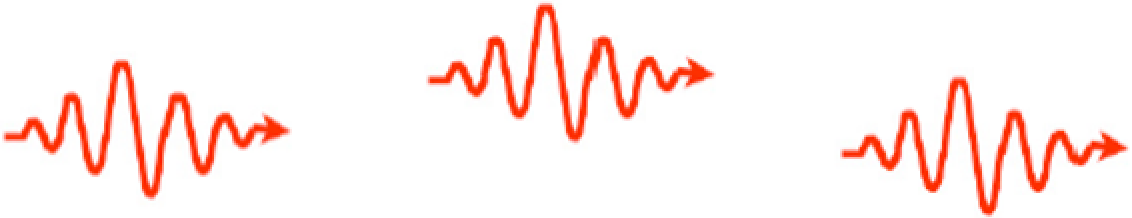




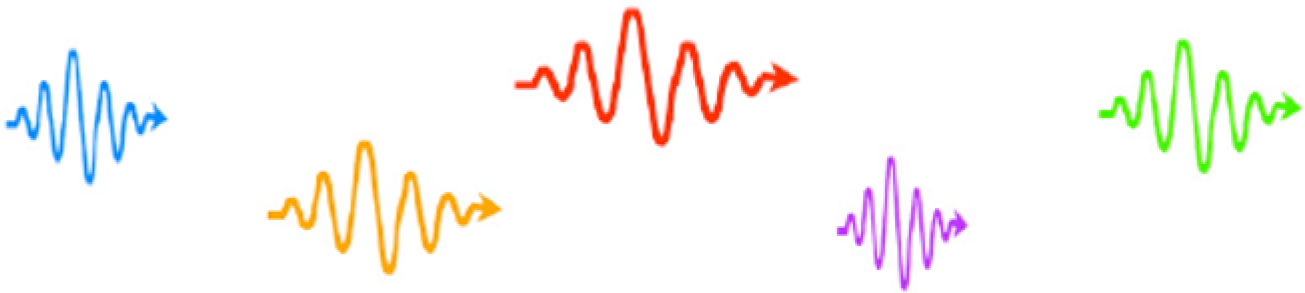
Photons (wave or energy packets)

Electromagnetic waves are composed of particle-like entities called *photons*.

Light also behaves like discrete particles called "photons"



"White light" (sunlight) contains all of the colors



Collectively, lots of photons with the same color (same wavelength) make an electromagnetic wave

$E = hf$ $\quad\quad c = \lambda f$ $\quad\quad p = h / \lambda$

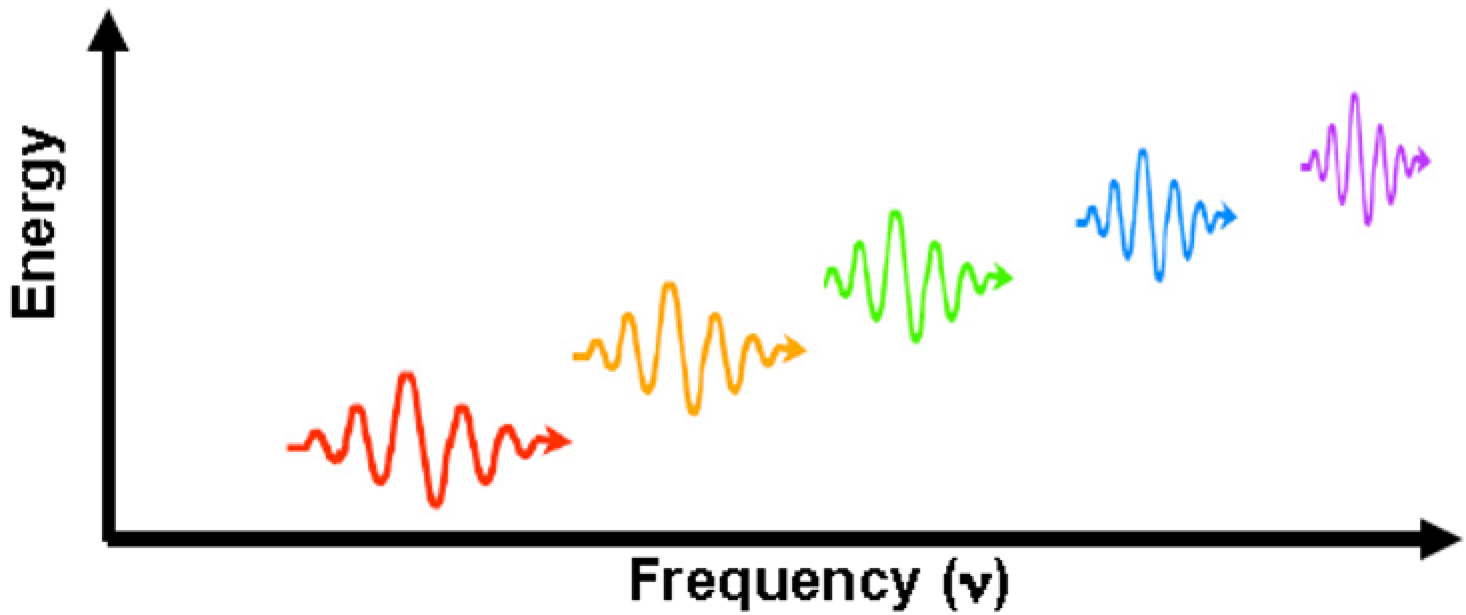
Energy (E) =frequency x h = frequency x 4.13 10^{-15} in eV
And frequency x wavelength = speed of light = 300,000,000
Frequency in Hz wavelength in meters speed of light in m/s

Values of h	Units	
$6.626070040(81)\times10^{-34}$	J·s	h for energy in joules
$4.135667662(25)\times10^{-15}$	eV·s	h for energy in electron-volts

1 = 1.60218e-19
Electronvolt Joule

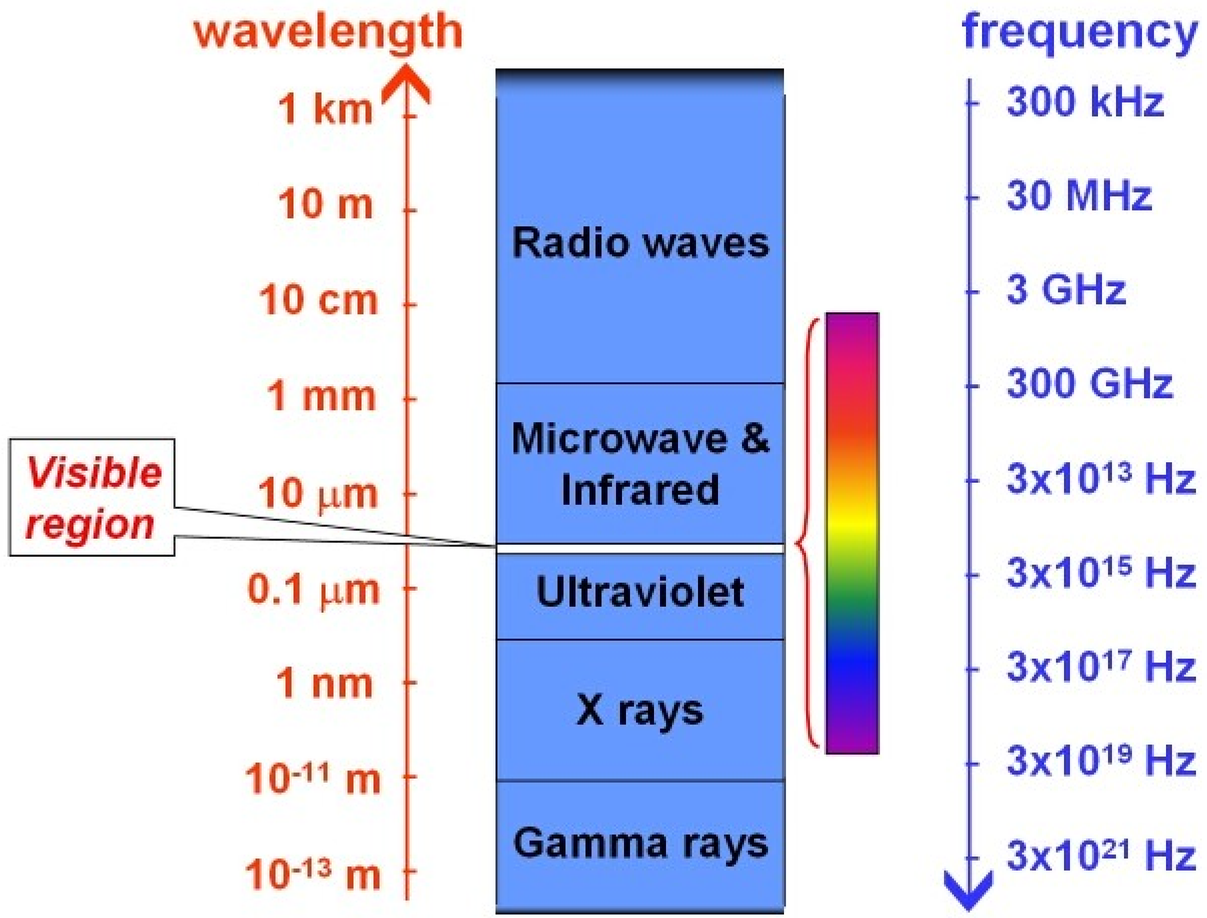
A photon has no mass, but its energy is E = hν

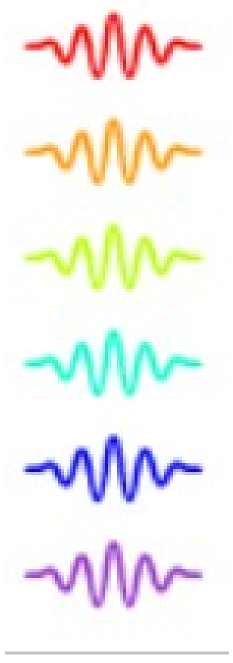
h = "Planck's constant," which is a VERY small number (6.63 x 10-34 in our units).



Photons of higher energy (E) have a higher frequency (ν) and shorter wavelength (λ)

Energy (E) =frequency x h = frequency x 4.13 10^{-15} in eV
And frequency x wavelength = speed of light = 300,000,000
Frequency in Hz wavelength in meters speed of light in m/s





Visible photons

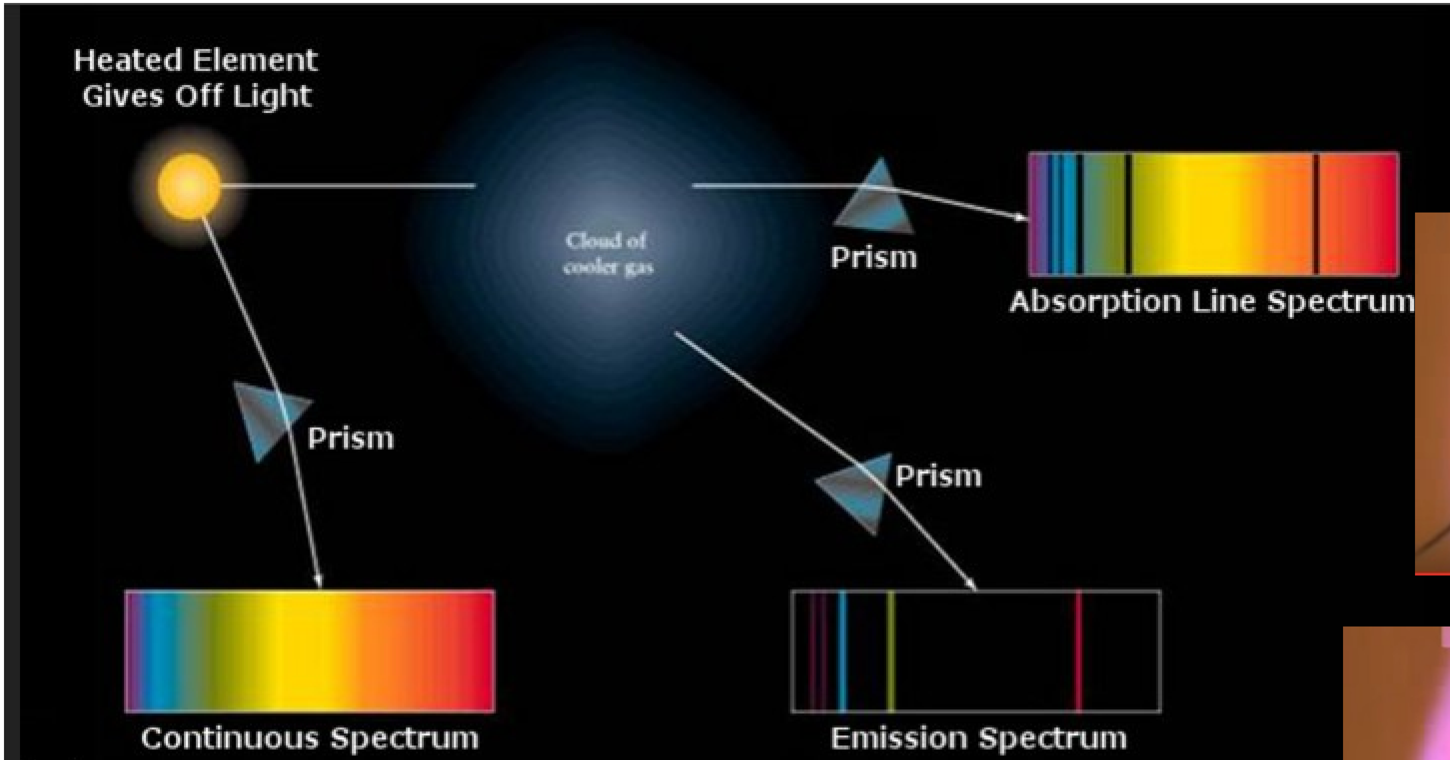
Region	Wavelength
Hard gamma	1×10^{-9} nm
Gamma	1×10^{-6} nm
Gamma/X-ray	0.001 nm
X-ray	1 nm
X-ray/**Ultraviolet**	10 nm
Ultraviolet	100 nm
Visible (blue)	400 nm
Visible (red)	700 nm
Infrared	10000 nm
Microwave	1 cm
Microwave/Radio	10 cm
Radio	100 m
Radio	100 km

Find the frequency and energy in eV

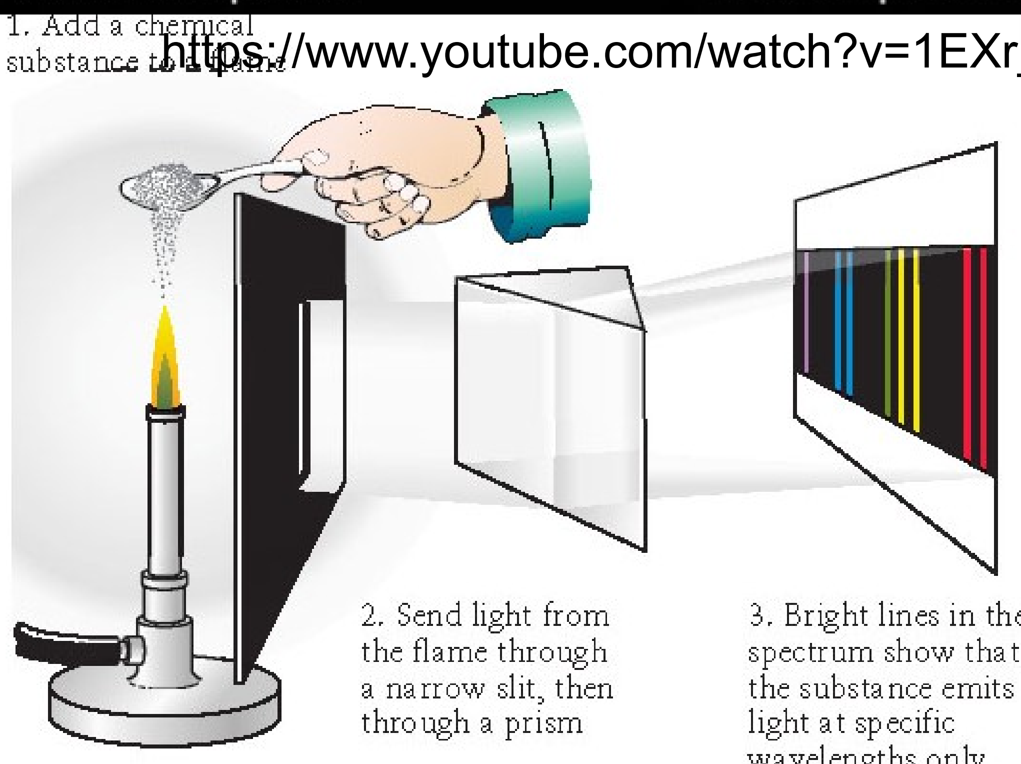
For each region

1nm = 10^{-9}m
1cm=0.01m
1km=1000m

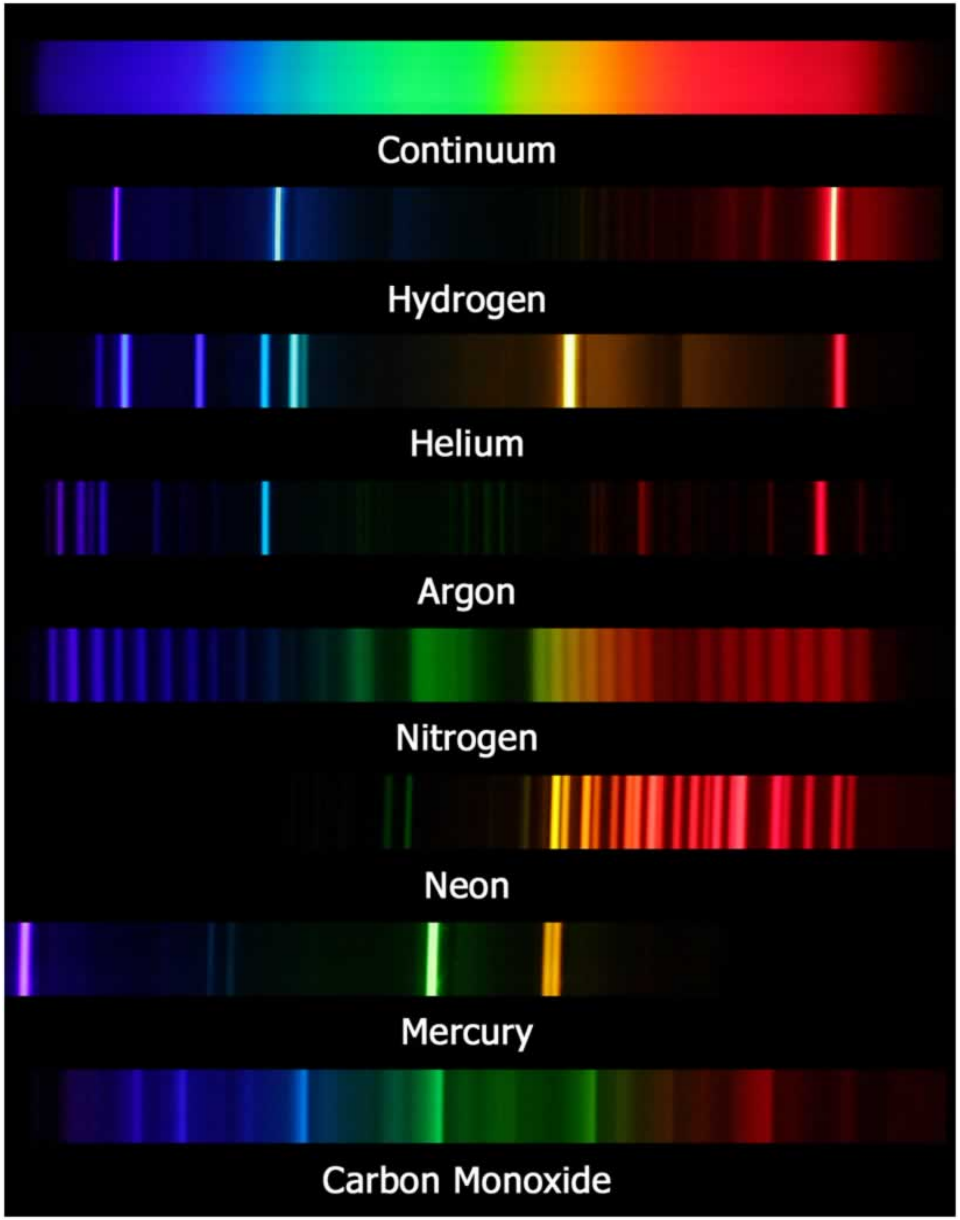
Energy (E) =frequency x h = frequency x 4.13 10^{-15} in eV
And frequency x wavelength = speed of light = 300,000,000
Frequency in Hz wavelength in meters speed of light in m/s



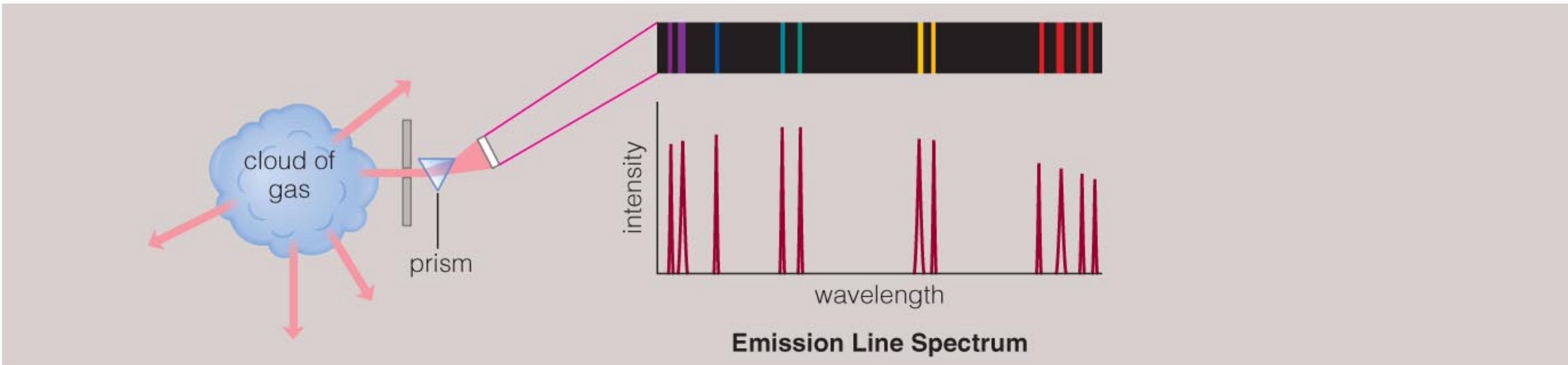
https://www.youtube.com/watch?v=1EXr_L7Ojqg



Chemical Fingerprints



During the lab:
you worked with a hot gas and got
Emission Line Spectrum



A thin or low-density cloud
of gas emits light only at
specific wavelengths that
depend on its composition
and temperature,
producing a spectrum with bright
emission lines.

apps

file:///C:/Users/Veronique/Dropbox/website_onlinephys/onlinephys.com/05_ProductionOfAbsorpLines.htm

file:///C:/Users/Veronique/Dropbox/website_onlinephys/onlinephys.com/IF_05_15_EmissionLine.htm

file:///C:/Users/Veronique/Dropbox/website_onlinephys/onlinephys.com/emlinespec.gif Emission vs absorption

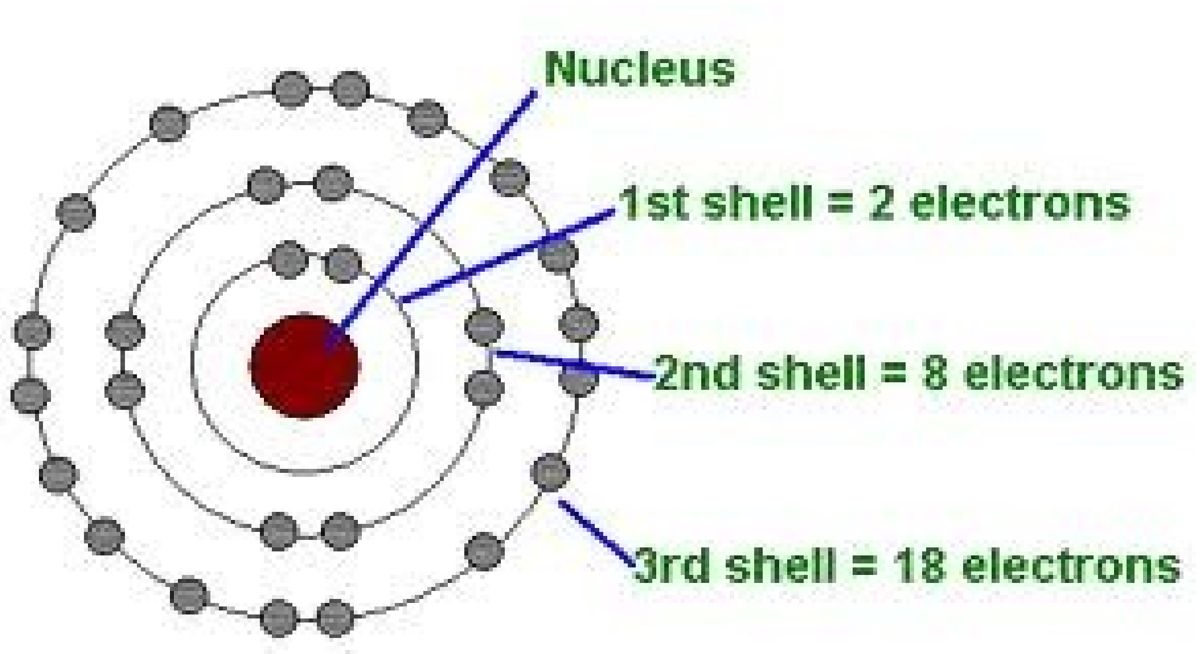
https://www.youtube.com/watch?v=I4yg4HTm3uk Spectrum of star emission-absorption

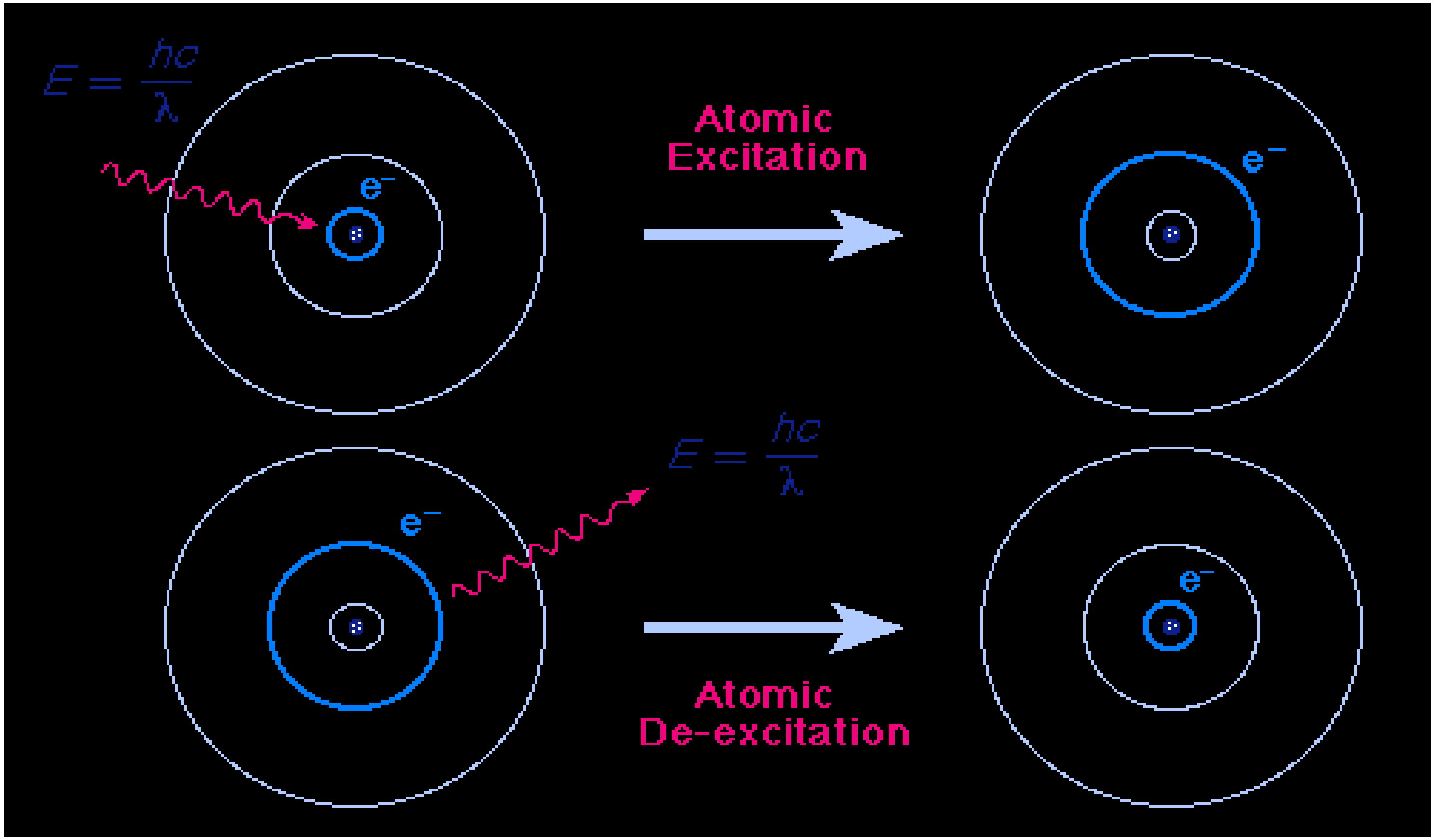
http://chemistry.bd.psu.edu/jircitano/periodic4.html excellent periodic table of elements with spectrum for each element

http://highered.mheducation.com/olcweb/cgi/pluginpop.cgi?
it=swf::800::600::/sites/dl/free/0072482621/78778/Spectroscopy_Nav.swf::Stellar Spectroscopy Interactive

See exploration app – model ot atoms

Bohr model of the atom

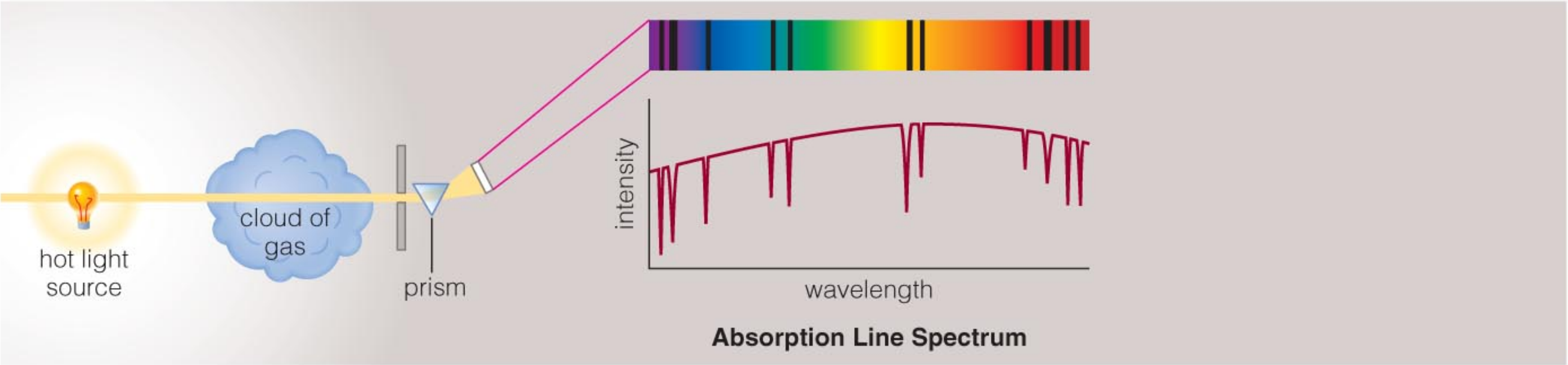




Energy photon= difference of energy levels between 1 and 2= h x frequency
Like a parking meter. (like 17 cents is not allowed). The atoms recognize the photons or not. If a photon encounters an atom and if the photon is recognized by the atom then it is absorbed. The photon is recognized only it is has the right energy. The energy has to be equation to the energy necessary to Transit from one energy level to a higher one. Other wise if passes unimpeded

SOME PHOTONS PASS WITHOUT BEING ABSORBED
Energy photon absorbed = E4 – E3 = h x frequency
So in the spectrum the green will be missing = absorption line.
The photon will be remitted but in another direction.
So green Is missing from the spectrum

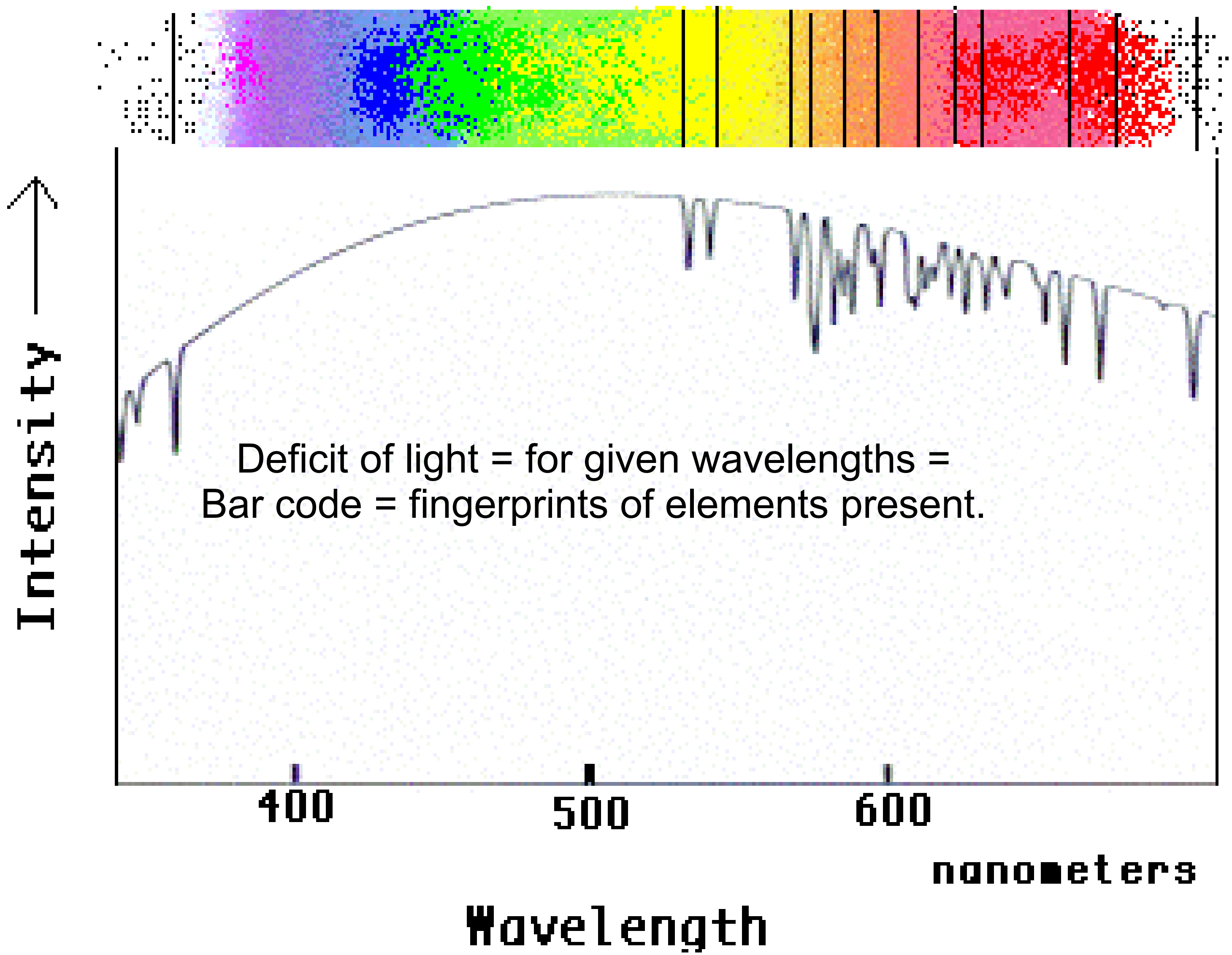
Absorption Line Spectrum



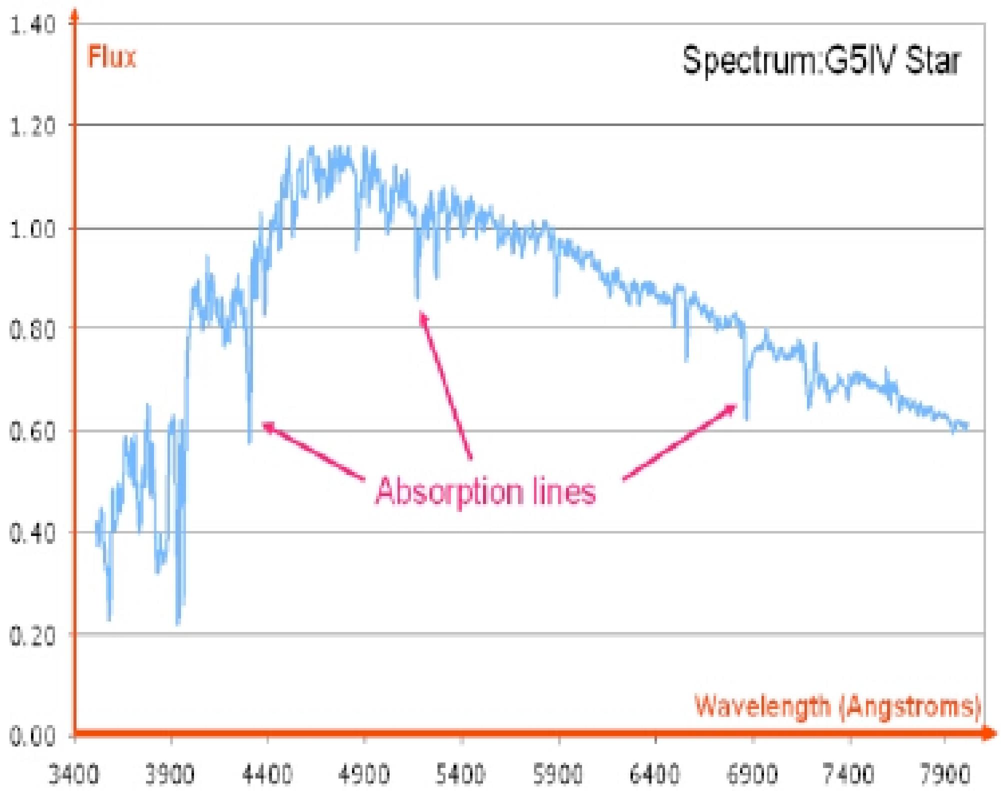
- A cloud of gas between us and a star (light bulb) can absorb light of specific wavelengths, leaving dark absorption lines in the spectrum. These lines are fingerprints for what is inside the cloud.

Watch video about spectrum of stars (not Bill Nye)

**A Star (or any hot body called thermal emitter) produces
A continuum of light with superimposed black lines called
Absorption lines. These lines are the fingerprints of atoms found
In the atmosphere (cooler) of the stars. They tell us what components of
The star. This how we found out about helium. (found in the Sun).**

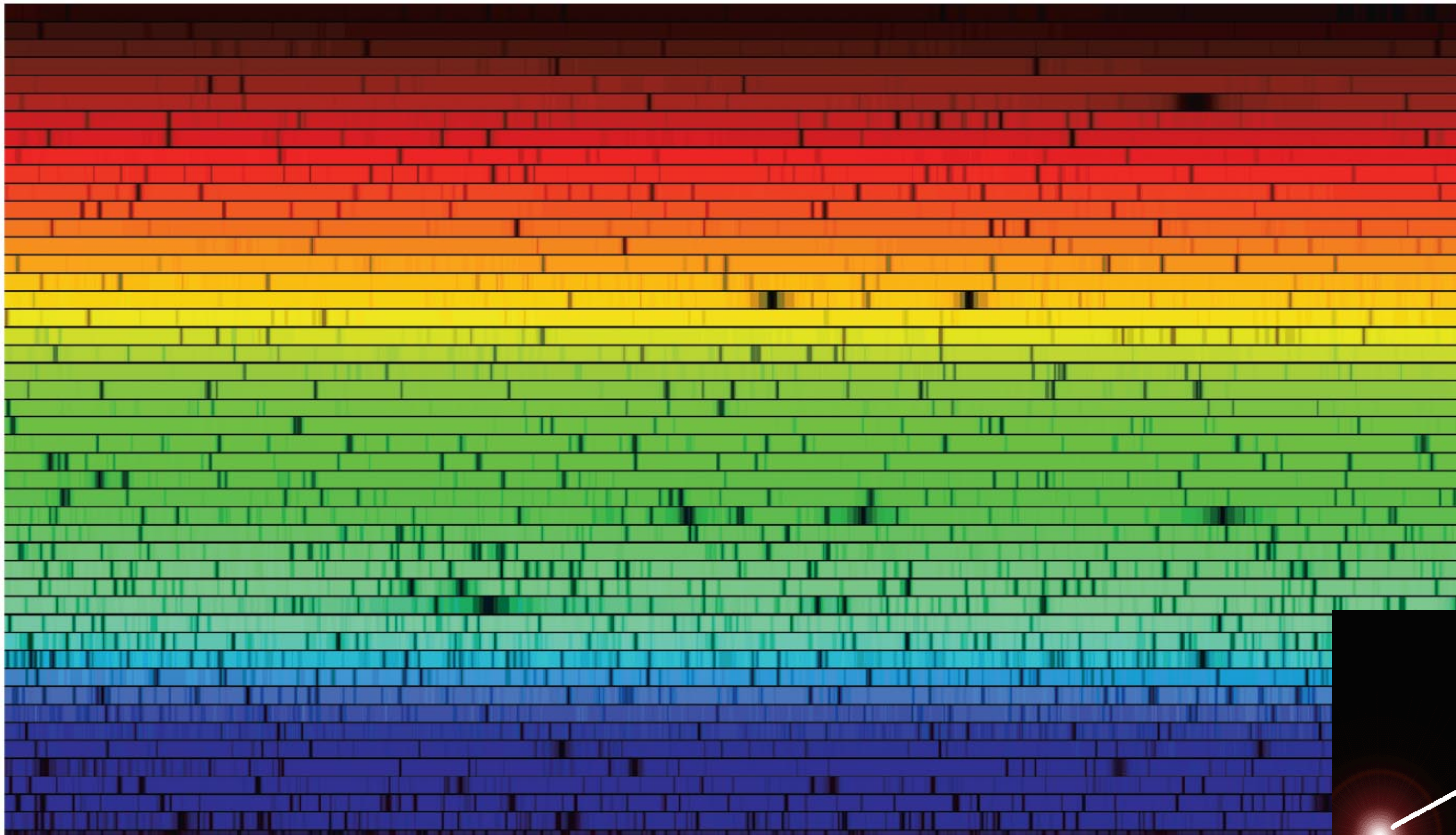


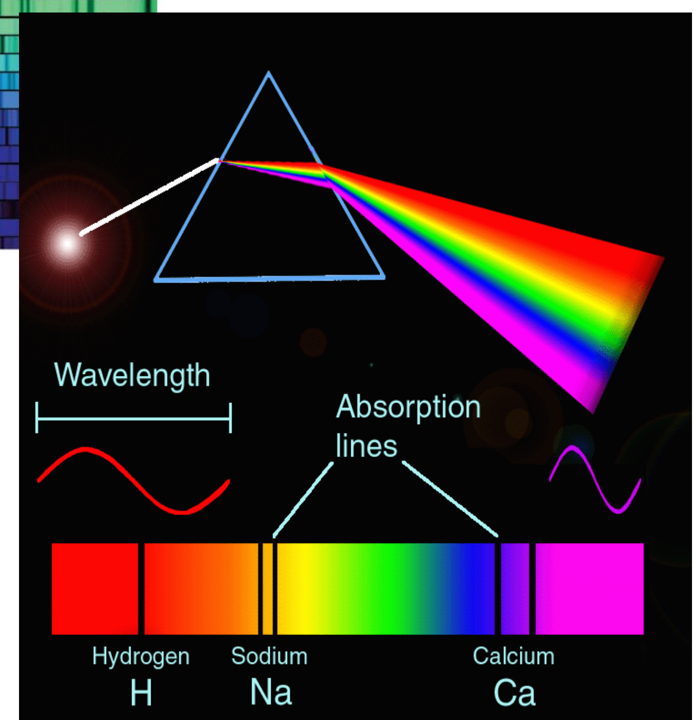
The spectrum from a star looks more like this:



A continuum and superimposed absorption lines

Absorption lines are code bar. You have to be a trained spectroscopist to read the code!

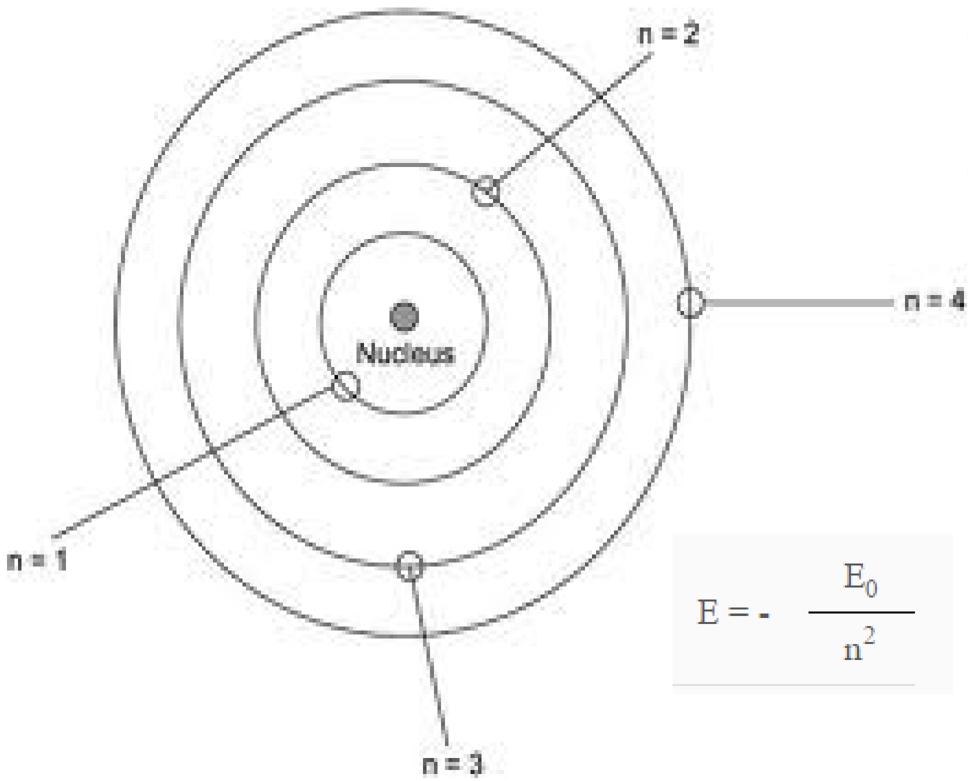




Light from celestial objects go through a prism and we get absorption lines superimposed to A “rainbow”/

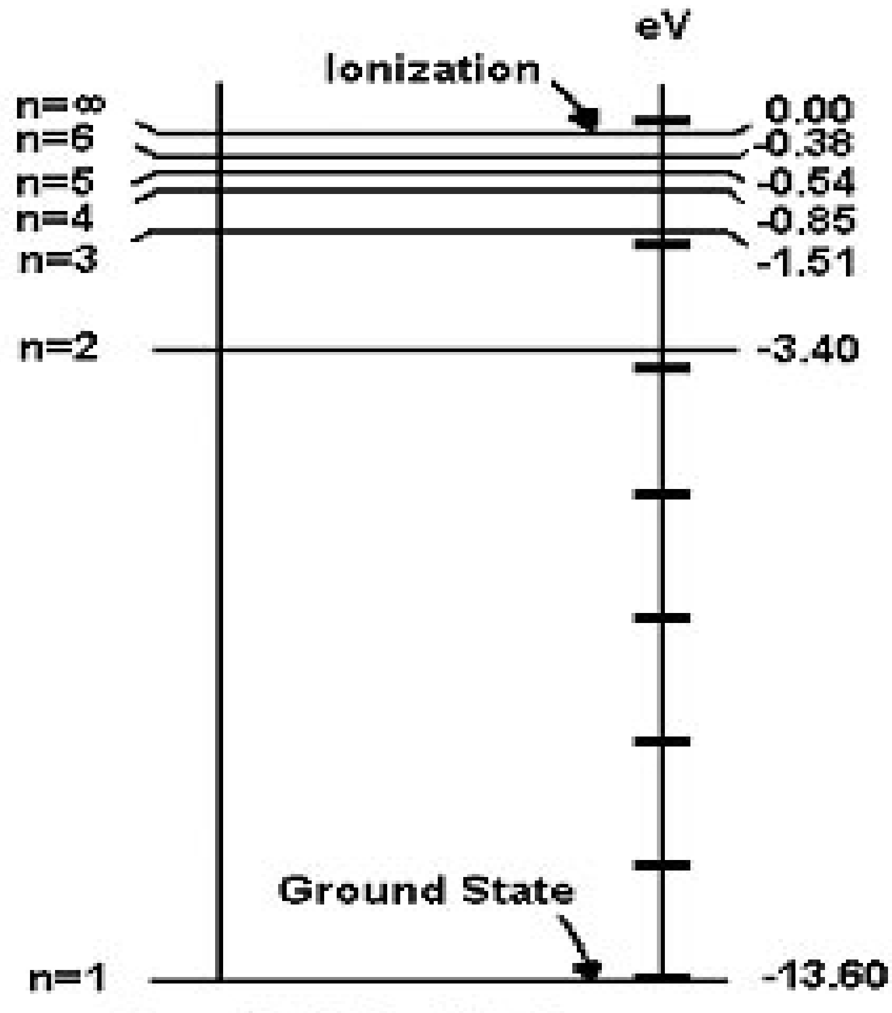
Electrons in atoms exist only in particular energy levels

Energy is quantized

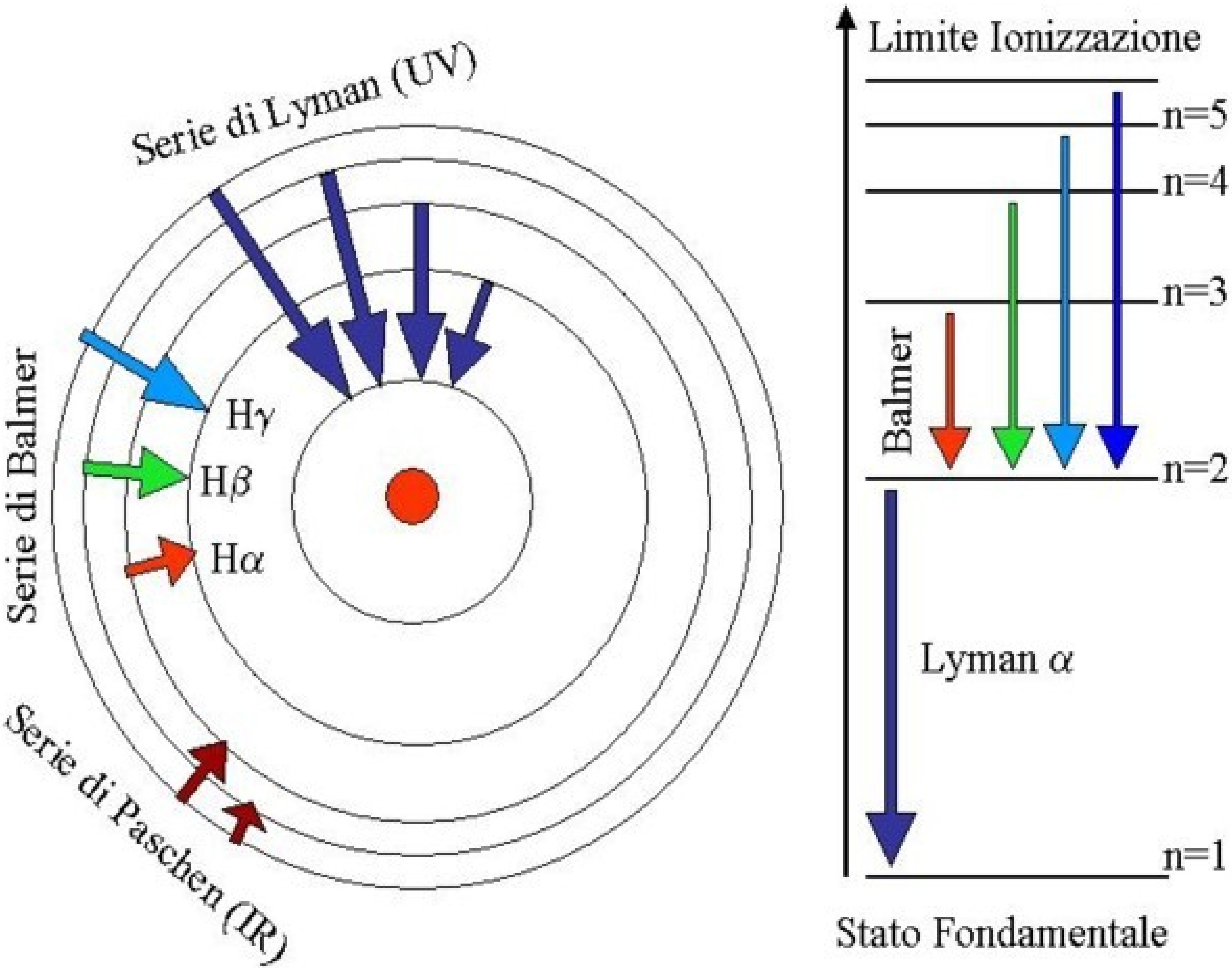


$$E = -\frac{E_0}{n^2}$$

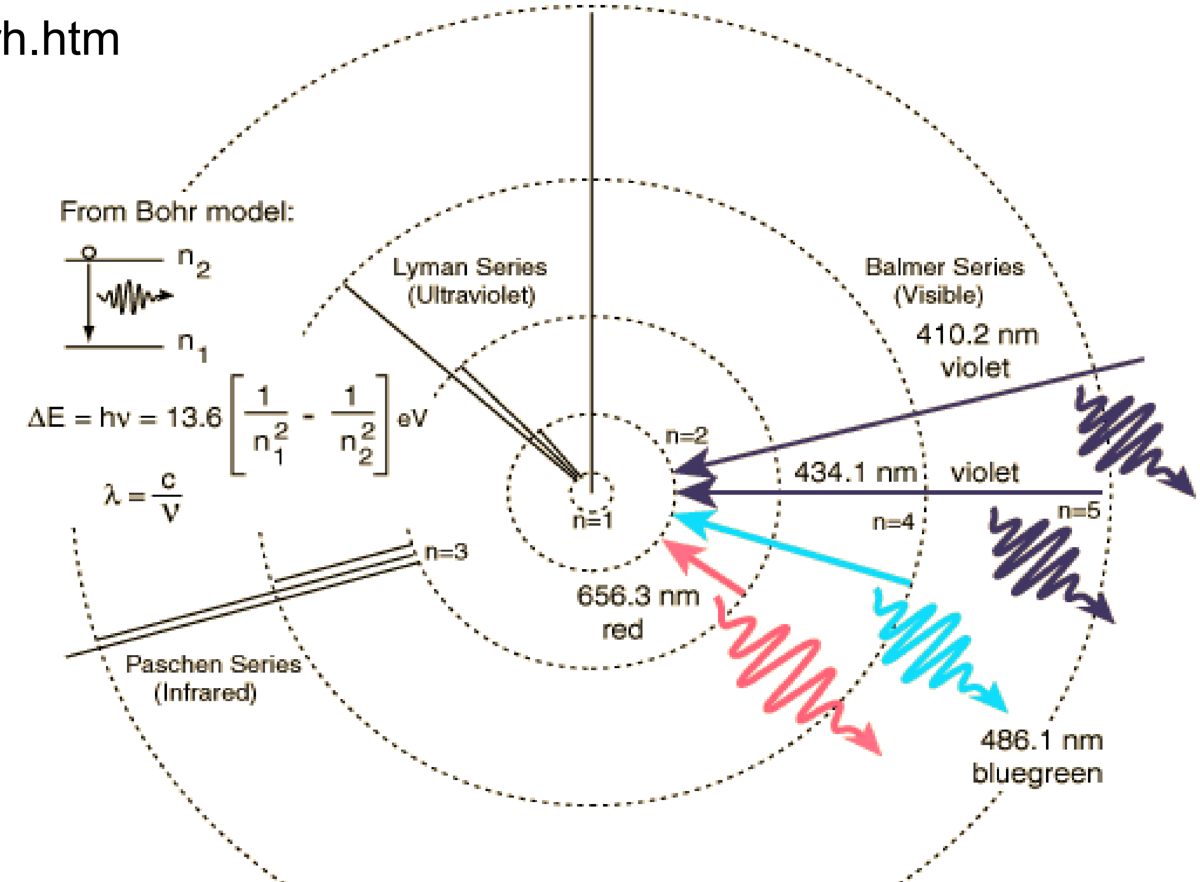
$$E_{photon} = E_0\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

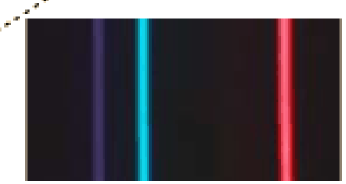


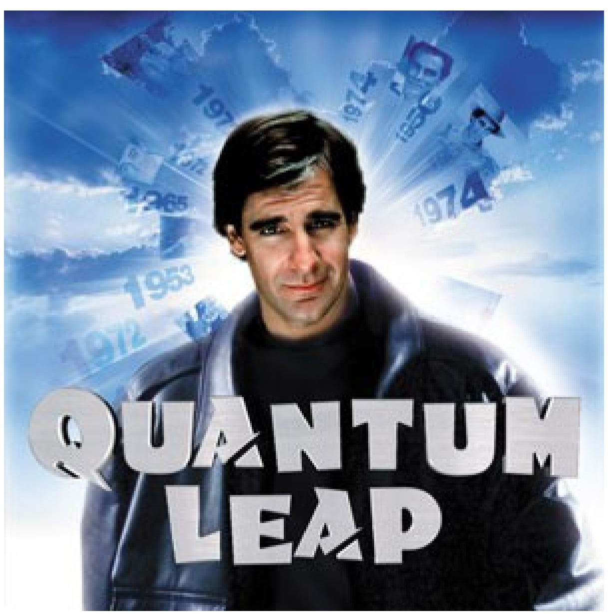
Electrons can jump back in several steps. Emitting more than one photon.



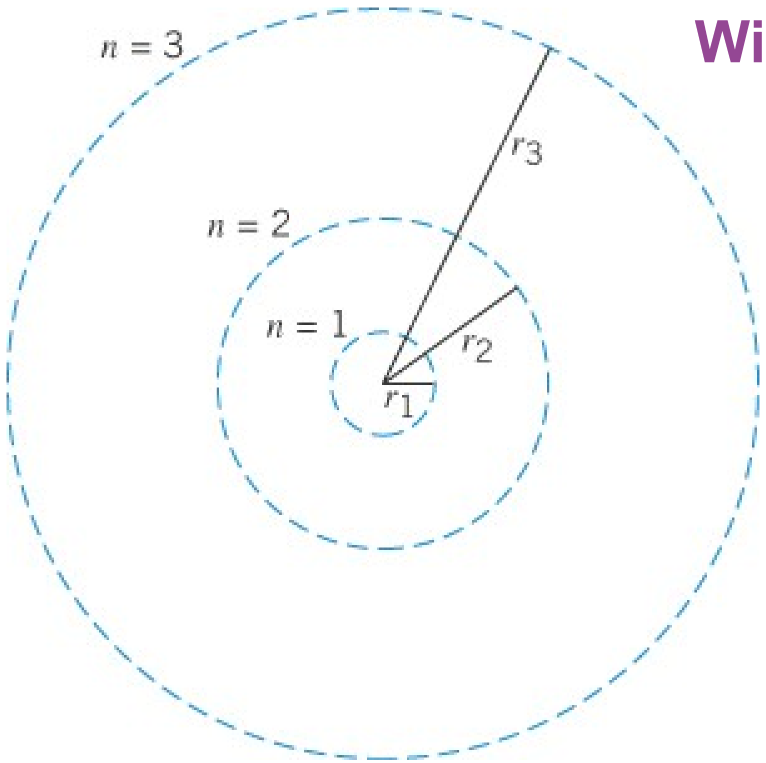
http://www.walter-fendt.de/ph14e/bohrh.htm







Energy level transitions, in which an electron moves From one energy level to another, can occur only When the electron gains or loses just the right Amount of energy.



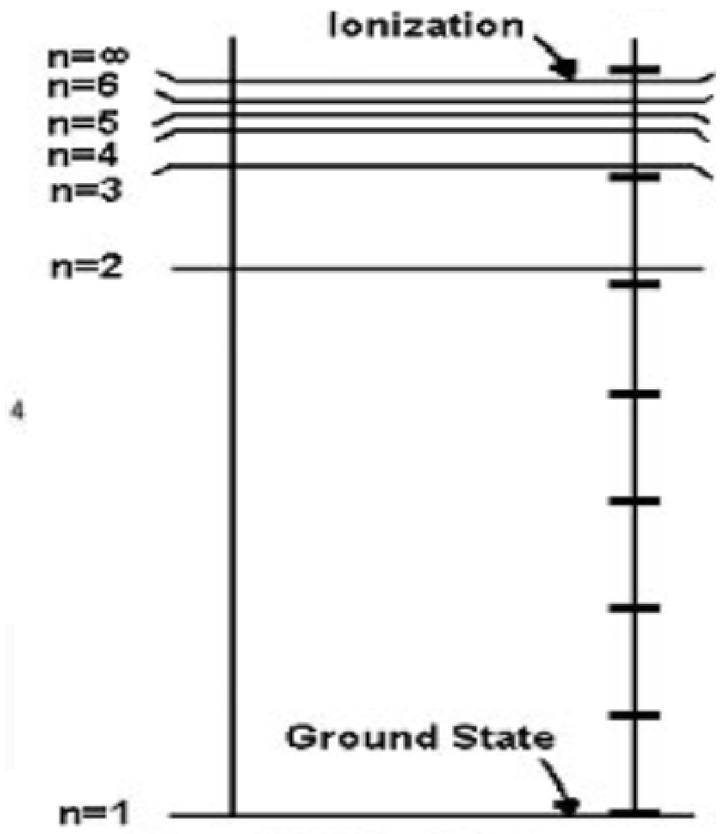
The formula works for the hydrogen atom or For an element that lost electrons and is left With only 1 electron.

Bohr energy levels

$$E_n = -\left(2.18\times10^{-18}\,\mathrm{J}\right)\frac{Z^2}{n^2} \quad n = 1, 2, 3, \ldots$$

$$E_n = -\left(13.6\,\mathrm{eV}\right)\frac{Z^2}{n^2} \quad n = 1, 2, 3, \ldots$$

Bromine	many green lines	
	481.7	green
	478.6	blue
	470.5	blue
	many purple lines	
Calcium	445.4	blue
	443.4	blue-violet
	442.6	violet (strong)
	396.8	violet (strong)
	393.3	violet (strong)
Chromium	520.8	green
	520.6	green
	520.4	green
	428.9	violet (strong)
	427.4	violet (strong)
	425.4	violet (strong)
Copper	521.8	green
	515.3	green
	510.5	green
Hydrogen	656.2	red
	486.1	green
	434.0	blue-violet
	410.1	violet
Helium	706.5	red
	667.8	red
	587.5	orange (strong)
	501.5	green
	471.3	blue
	388.8	violet (strong)
Potassium	404.7	violet (strong)
	404.4	violet (strong)
Lithium	670.7	red (strong)
	610.3	orange
	460.3	violet
Sodium	589.5	yellow (strong)
	588.9	yellow (strong)
	568.8	green
	568.2	green
Neon	many lines in the red	
	640.2	orange (strong)
	585.2	yellow (strong)
	583.2	yellow (strong)
	540.0	green (strong)
Strontium	496.2	blue-green
	487.2	blue
	483.2	blue
	460.7	blue (strong)
	430.5	blue-violet
	421.5	violet
	407.7	violet
Xenon	492.3	blue-green
	484.4	blue
	482.9	blue
	480.7	blue
	469.7	blue
	467.1	blue (strong)
	462.4	blue (strong)
	460.3	blue
	458.3	blue
	452.4	blue
	450.0	blue (strong)



Energy levels for the hydrogen atom

1) The electron of hydrogen is bound to its nucleus (proton). It is trapped In a " well" .

A) Use the equation $E_n = -13.6 / n^2$ to find the energy associated to the levels: 1,2,3,4 5. The electron can get to a higher energy level if It is excited and absorbed the right amout of energy.

That are permitted for the electron to go it is excited.
For example n=1 is ground state E1=-13.6eV

B) Label the energy levels @ left with the corresponding energy in eV

C) The electron jumps from level 3 to level 1 and emits a photon
What is the energy " burped " in eV ? (E3-E1)

What is the frequency of the photon emitted ? (use E = f x h in eV)

What is the color of the photon ?
Use the table below (THz means 10^{12}Hz):

Color	Wavelength interval	Frequency interval
violet	~ 430 to 380 nm	~ 700 to 790 THz
blue	~ 500 to 430 nm	~ 600 to 700 THz
cyan	~ 520 to 500 nm	~ 580 to 600 THz
green	~ 565 to 520 nm	~ 530 to 580 THz
yellow	~ 590 to 565 nm	~ 510 to 530 THz
orange	~ 625 to 590 nm	~ 480 to 510 THz
red	~ 740 to 625 nm	~ 405 to 480 THz

D) Now the electron jumps from level 5 to level 4.
What is the energy of the photon emitted ? In eV
Use the link below to find its " color"

http://astronomy.swin.edu.au/cosmos/E/Electromagnetic+Spectrum

1) What is the wavelength of the spectral line produced when the electron of a hydrogen atom drops from the 4^{th} To the second quantum state ? (from n=4 to n=2 , use previous equation)

First find the energy in eV, find the frequency using E = f h , find the wavelength using c = f x wavelength

2) Find the wavelength of the UV photon when a hydrogen electron drops from its n=2 to its n=1 state

3) When the electron is in the n=4 level, what energies are possible for the photon emitted when the electron Drops to the lower level ? (so 4 to 3, 4 to 2, 4 to 1)

4) draw the situation. the single electron in an atom has an energy of -40eV when it;s in the ground state, and the first excited state for the electron at -10 eV. What will happen to this electron if the atom is struck by a stream of photon ff energy 15eV ?

5) Helium emits 3 strong lines of color positioned at :
447 nm, 502nm and 588nm. Use the table from previous slide find the corresponding colors.

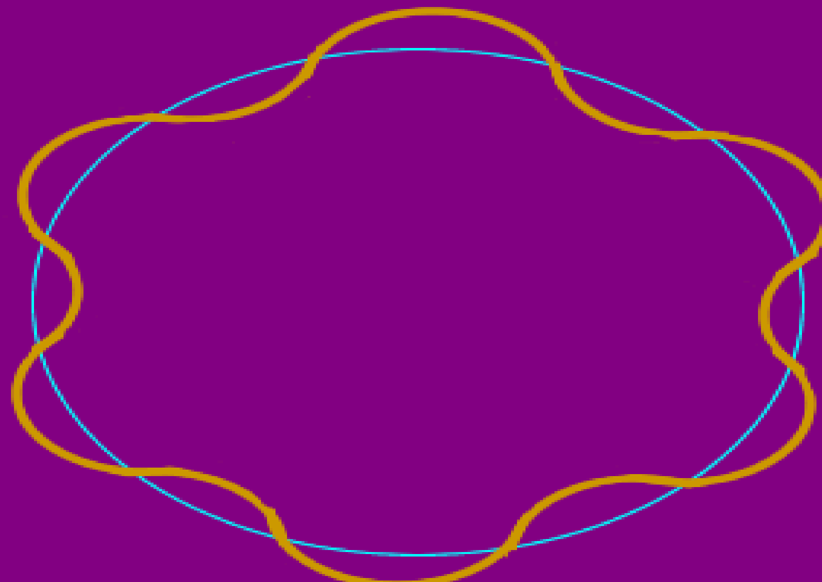
6) The prominent mercury lines are at 435.835 nm , 546.074 nm , and a pair at 576.959 nm and 579.065 nm What are colors of the lines?

7) here are the energy levels for mercury. If an electron humps from level 3 to level2. What is the energy Of the photon emitted . What is frequency. What is its color ?

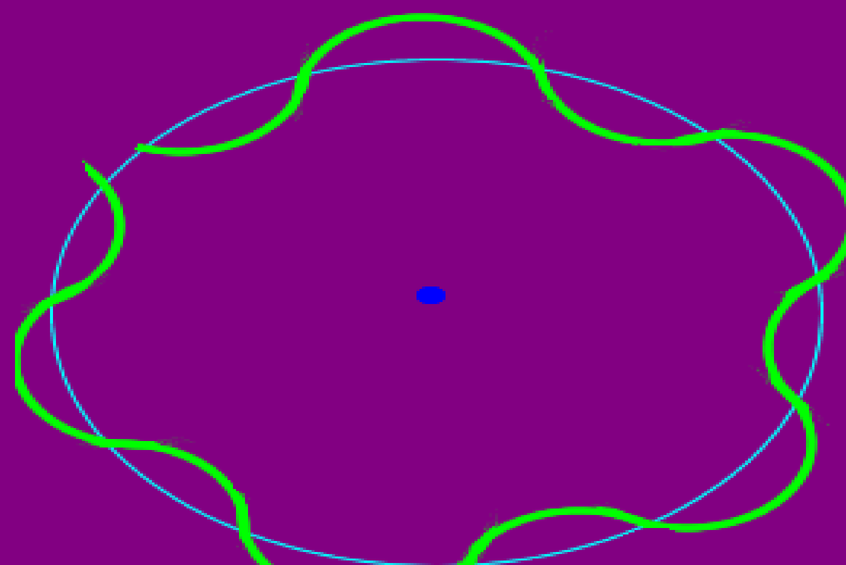
Energy Levels for Mercury	
n	Energy (eV)
1	−10.38
2	−5.74
3	−5.52
4	−4.95
5	−3.71

Same question for level 5 to 1

rench physicist by the name of Louis de Broglie proposed that just as light, a
n previously thought to be wave-like, also had particle-like characteristics, so
s, entities thought to be solely particle-like, also have wave-like
ics. De Broglie believed that there should be such a symmetry in nature and
in his Ph.D. dissertation. De Broglie said that the Bohr Model worked
ctrons would occupy standing waves when orbiting the hydrogen atom.



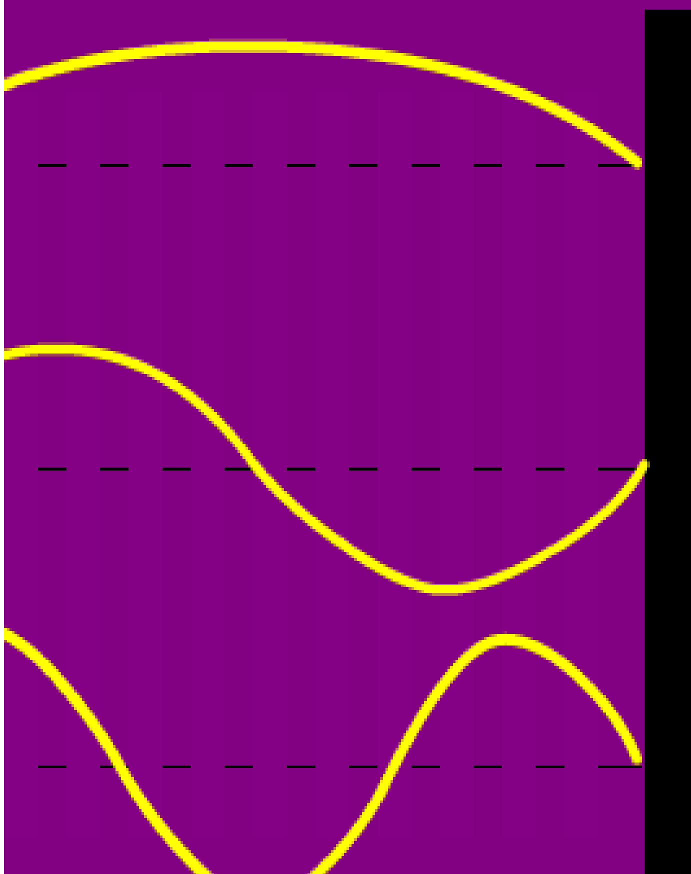
An example of a
circular standin



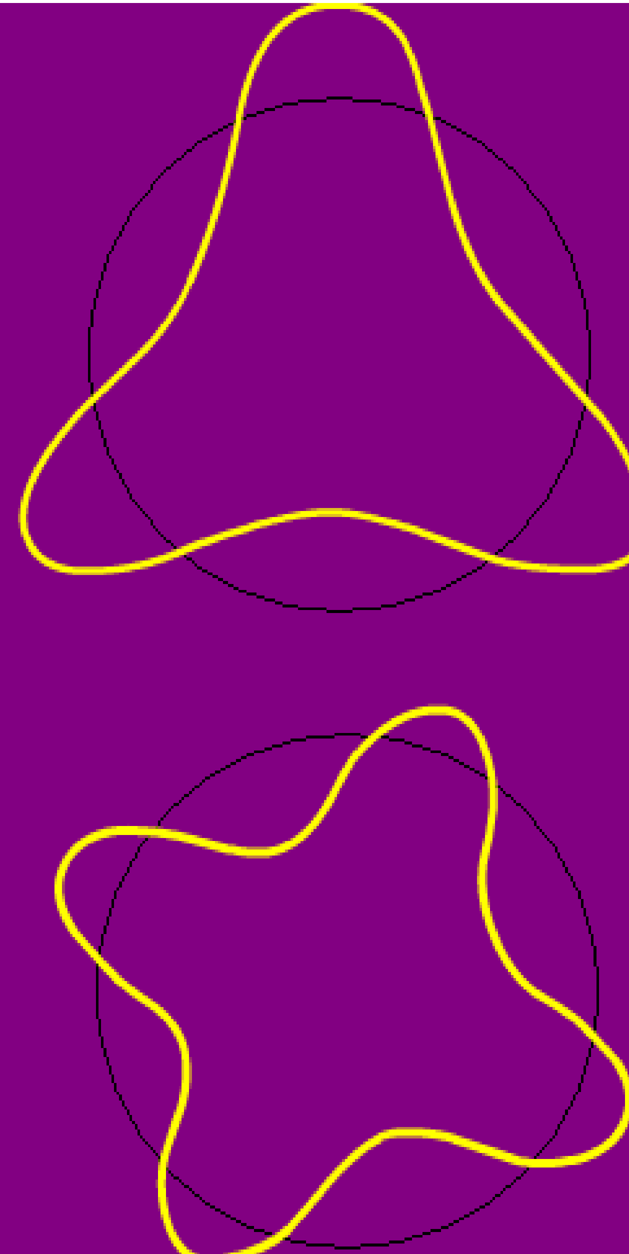
An example of
not a standing

uis de Broglie suggested that just as light, previously
oe solely wavelike, had particle-like properties, it was
at electrons, previously thought to be solely particle-
ave-like properties. De Broglie stated that electrons in
ccupied stable orbits because it was in those orbitals
ctrons could have a standing wave-like structure. The
ibsequently asked was, "A wave of what?"

$$2 \pi r = n \lambda$$



Snapshots of various standing waves along strings fixed at both ends



Snapshots of circular standin
waves; these shapes are wha

quation for the hydrogen atom. His mathematical on led to many answers about the behavior of rogen atom and, by extension, the behavior of all er elements.

Shapes of some of the probability wavefunctions of electrons in orbit about a hydrogen atom