ASTR 1020
Introductory Astronomy 2: Stars & Galaxies
January 25, 2008

Professor **Jack Burns**

Newcomers - All class info is at website:
http://solo.colorado.edu/~jaburns/Astr1020Sp08/index.html

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Astronomy In the News: CU-BOULDER SPACE SCIENTISTS READY FOR MESSENGER MISSION FLYBY OF MERCURY

- For more information on the MESSENGER mission, including images, photos, animation and videos, visit the Web at: http://messenger.jhuapl.edu/. For more information about LASP, visit the Web at: http://lasp.colorado.edu/.

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Homework

- **Reading**: Chapter 5, sections 5.3- 5.5; summary of key concepts.
- *MasteringAstronomy* Tutorials & Exercises – Scales of the Universe (complete by Jan. 28). For calculation problems, *use at least 3 significant digits* – example: 1.34 or 134. Correct answer has to be within 2%.
- Clicker points start on Monday!

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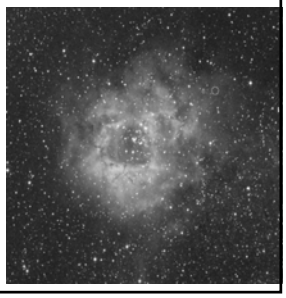
Today's Class

Chapter 5: Matter and Light

- Atoms and Molecules
- Light Waves and Particles
- The Electromagnetic Spectrum



Matter: a Material World

Atoms: nucleus made of protons and neutrons

A surrounding cloud made of electrons (please try to get rid of the "solar system" vision of atoms!)

Electrons are held onto the atom by electric force. Electrons have negative electric charge, protons are positive. Neutrons are neutral.

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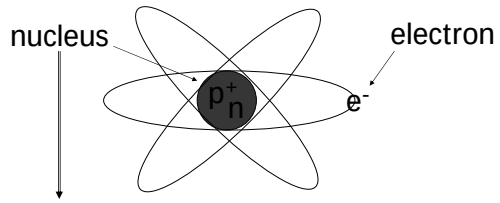
Atom



protons

neutrons

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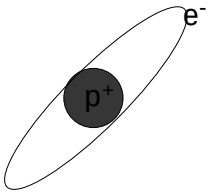
Hydrogen: simplest and most common



atomic number = 1

atomic mass number = 1

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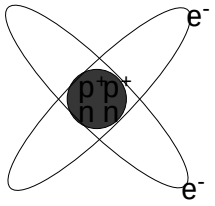
Helium



atomic number = 2

atomic mass number = 4

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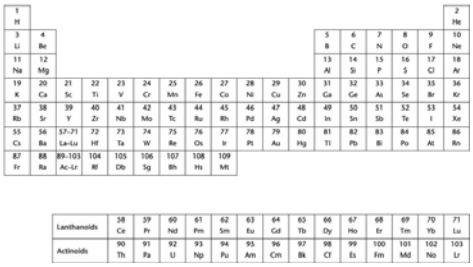
Periodic Table of the Elements



atomic number = #protons

atomic mass no. = #protons + #neutrons

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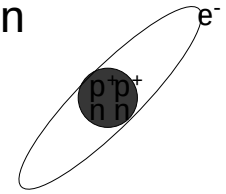
What if an electron is missing?

ion



atomic number = 2

atomic mass number = 4

He^{+1}

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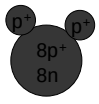
What if two or more atoms combine to form a particle?

molecule



H_2O (water)

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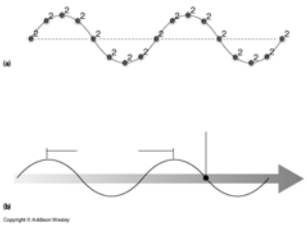
Wave Nature of Light

"Speed of light" = c = 300,000 km/sec.

Wavelength of light is the distance from crest to crest = λ ("lambda"), measured in meters.

Frequency, f, is how many wave peaks pass by in 1 second (cycles per second)

f = c / λ.



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Particle Nature of Light

- Light can also be thought of as a particle
  → "photon"

A photon is a mass-less particle of electromagnetic radiation energy

????? Dual nature of light ?????
"wave-particle duality"
Seen in other particles (e.g., electrons) as well

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Photons can have any energy from tiny to gigantic

The greater the energy of the photon (E), the higher the frequency, smaller the wavelength:

$E \sim f$ $E \sim 1 / \lambda$

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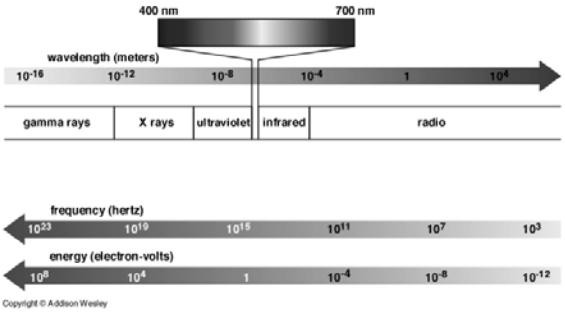
The Electromagnetic spectrum

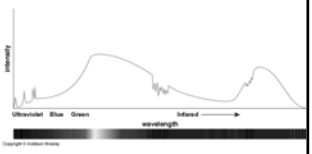


video

Spectra and spectral analysis

- A spectrum shows the intensity of light versus wavelength, frequency OR energy

Can be created by passing light through a prism or other optics



Spectral analysis uses what we know about how light is emitted by and interacts with matter- by looking at the light's spectrum, we can tell something about its source

Note: rainbow is only accurate for Visible light; IR and UV are invisible and have no color!

Note dark bands where light is absent and areas where light is more intense

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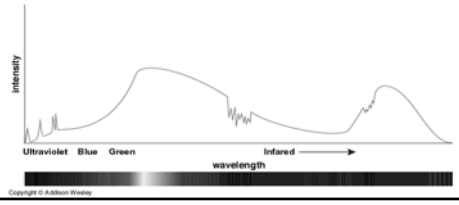
Clicker Question

From the spectrum shown here:

A) Most light is being emitted in the infrared
B) The color of the object to our eyes would be blue-ish
C) The color to our eyes would be very dark red
D) The object would have faint stripes
E) None of the above



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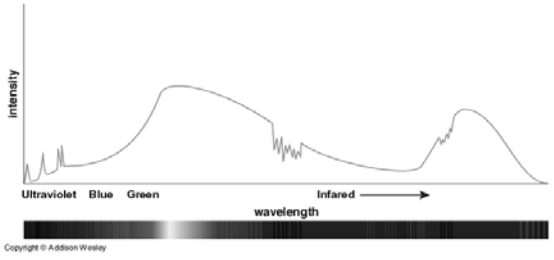
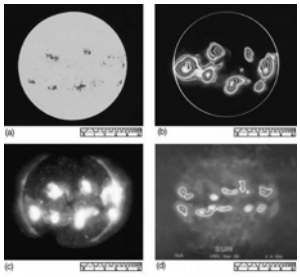
- E: None of the above. The color in visible light would be yellow/orange, with some invisible emission in the infrared. The fine features would not be discernable to our eyes.



- Objects can look very different depending on the wavelength of light you are detecting:
- Sun as seen in visible, UV, X-ray and radio light



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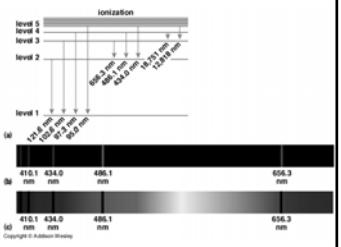
Emission from Atoms

- IF electrons are in a high energy state, they can transition to a lower energy state by emitting a photon of the according energy. Energy is conserved!



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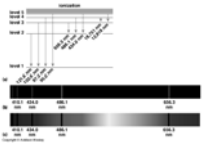
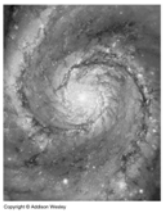
- Each atom has a different set of energy levels → different emission/absorption spectrum
- Examples: mercury, sodium, neon, hydrogen, mercury….
- Demo: diffraction grating spectroscopes

Most common visible light emission line





- "Hydrogen Alpha"
- n=3 to n=2 energy jump at 656.3 nm
- The universe is mostly pink!!