

ASTR 1020 Introductory Astronomy 2: Stars & Galaxies

Sep. 6, 2013

Professor
Jack Burns



Newcomers - All class info is at website:

<http://lunar.colorado.edu/~jaburns/astr1020>

Notes from last week's classes are posted on the class website.

Astronomy In the News

Lauren Finn

"Curiosity" Mars Science Laboratory

With a length of 9 feet (2.7 m) and weight of 3,994 pounds (1800 kg), the nuclear powered rover "Curiosity" will carry a payload of scientific experiments more than ten times as massive as earlier Mars rovers.

ChemCam will fire a laser and analyze the elemental composition of exposed materials from areas smaller than 1 millimeter on the surface of Martian rocks and soils.

MASTC Nuclear Power Source contains 12 pounds (4.8 kilograms) of plutonium dioxide.

Robotic Arm (RACV) instruments in contact with the Martian soil. Instruments include the **Alpha Particle X-ray Spectrometer (APXS)** and the **Mars Hand Lens Imager (MHLI)**, as well as devices associated with sample acquisition and preparation.

Six wheels, each with its own individual motor. The two front and two rear wheels also have individual steering motors, which allow the vehicle to turn in place a full 360 degrees.

Source: JPL PROPULSION LABORATORY
Graphic by Karl Tate

Homework

- **Reading:** Chapter 5, sections 5.3- 5.5; summary of key concepts.
- *MasteringAstronomy* Homework – **Scales of the Universe** (complete by tonight at midnight!).
- **Clicker points start next Monday!**
- Please volunteer for *Astronomy in the News* presentation!

Today's Class

Chapter 5: A Review of Light

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



Question from Reading Why is a rose red?

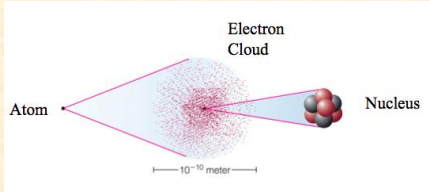
- The rose absorbs red light.
- The rose transmits red light.
- The rose emits red light.
- The rose reflects red light.

Question from Reading Why is a rose red?

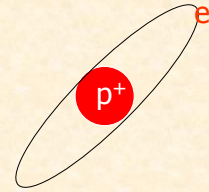
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Matter: a Material World

- **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**.

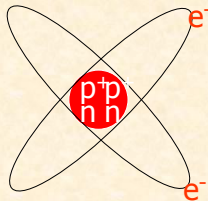


Hydrogen: simplest and most common



atomic number = 1
atomic mass number = 1

Helium



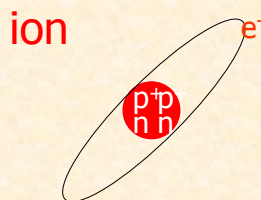
atomic number = 2
atomic mass number = 4

Periodic Table of the Elements

1																	2
3	4											5	6	7	8	9	10
Li	Be											B	C	N	O	F	Ne
11	12											13	14	15	16	17	18
Na	Mg											Al	Si	P	S	Cl	Ar
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
55	56	57-71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Cs	Ba	La-Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
87	88	89-103	104	105	106	107	108	109									
Fr	Ra	Ac-Lr	Rf	Db	Sg	Bh	Hs	Mt									
		Lanthanoids		58	59	60	61	62	63	64	65	66	67	68	69	70	71
		Actinoids		90	91	92	93	94	95	96	97	98	99	100	101	102	103
				Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

atomic number = #protons
atomic mass no. = #protons + #neutrons

What if an electron is missing?



atomic number = 2
atomic mass number = 4 He^{+1}

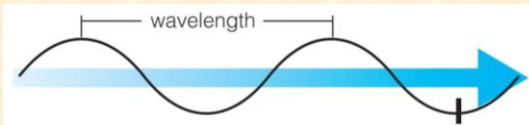
What if two or more atoms combine to form a particle?

molecule



H_2O (water)

Properties of Waves



- **Wavelength** is the distance between two wave peaks.
- **Frequency** is the number of times per second that a wave vibrates up and down.
- Wave speed = wavelength \times frequency.

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

Wavelength, Frequency, and Energy

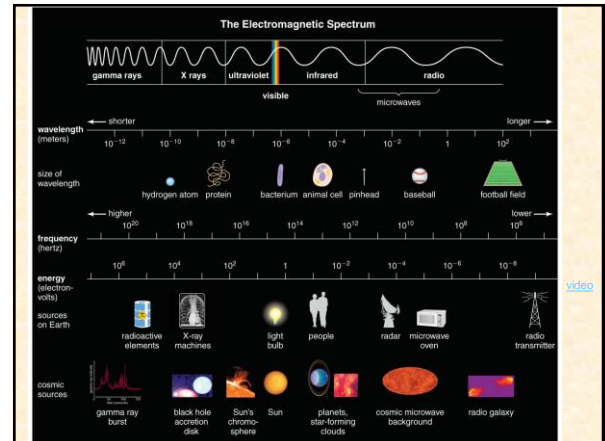
$$\lambda \times f = c$$

λ = wavelength, f = frequency

$c = 3.00 \times 10^8$ m/s = speed of light

$$E = h \times f = \text{photon energy,}$$

where h = Planck's constant

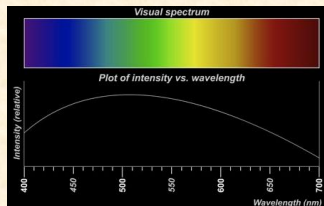


Spectra and spectral analysis

- 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

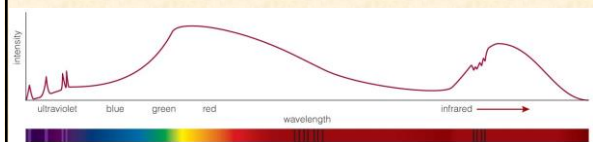


Note: rainbow is only accurate for Visible light; IR and UV are invisible and have no color!

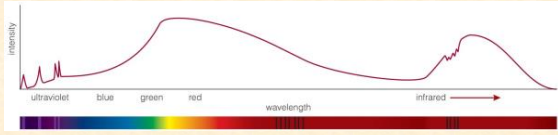
Clicker Question

From the spectrum shown here:

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

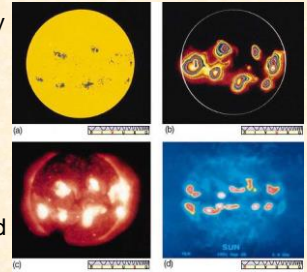


- **E: None of the above.** The color in visible light would be yellow/orange, with some invisible emission in the infrared. The fine features would not be discernable to our eyes.



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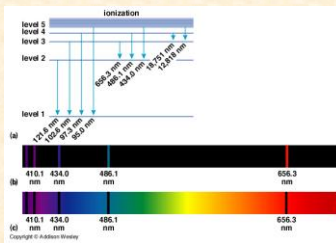
- Objects can look very different depending on the wavelength of light you are detecting:
- Sun as seen in visible, UV, X-ray and radio light



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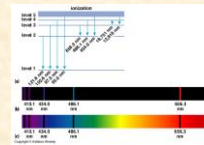
Emission from Atoms

- 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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Most common visible light emission line:



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

