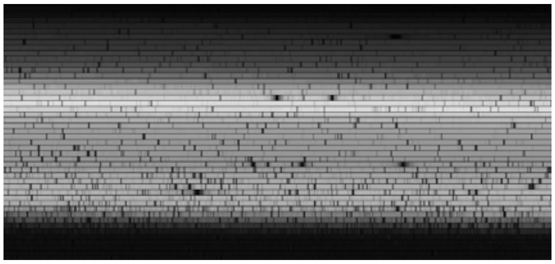
ASTR 1120: Stars & Galaxies



Prof. Juri Toomre   TA: Ben Brown

Lecture 4   Wed 19 Jan 05

zeus.colorado.edu/astr1120-toomre

Topics for Today

- Recall: as electrons pop from one level to another, yield `spectral lines': fingerprints are unique to each atom
- Kirchoff's "laws" + black-body emission spectrum
- Doppler effect
- Begin with telescopes

- *Observatory Night #2* tomorrow, Thur Jan 20 (at Sommers-Bausch Observ, next to Fiske and Kittredge) by sign-up (7pm, 8pm, 9pm)
- Forecast looks GOOD: Clear and warm!

Reminder *Homework Set 1*

- *Part A* involves going to book website, after login `joining our class' (cm228574 as in syllabus), doing the `*Light & Spectroscopy' tutorial* in Chap 6 while having your performance e-recorded (can repeat as often as wish). Complete by classtime this Friday. Web server for *astronomyplace* gets a bit clogged.

- *Part B* involves completing the `*Energy Level Diagrams & Spectral Lines'* problem sheet passed out in class last Fri. Due this Friday in class, no lates. Show how you got answers for Q 6-8 by staple-attaching worksheet.

Reading for Next Class

- Finish reading Chap 7, *Telescopes*
- Start reading Chap 15, *The Sun*

- *Check with us if any problems with your clickers*
- *Come see us if you need any help or advice with Homework Set 1, or with making your accounts active or with finding your way on www.astronomyplace.com*

Reading Clicker Q   *B*

What really is a light year ?

- *A. Year that has less calories*
- *B. Distance travelled by light in a year*
- *C. Time before some politicians tell the truth (as in "It will be many light years before the truth is known..")*
- *D. Travel time for light to get to us from the Sun*

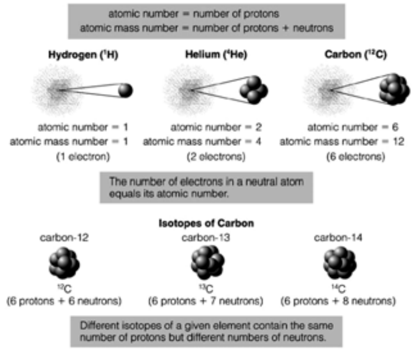
Light year ?

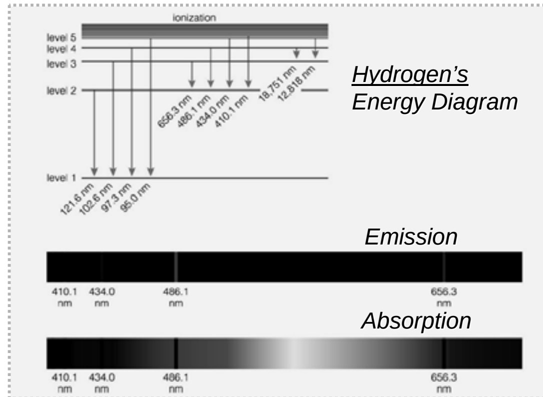
- *B. DISTANCE travelled if moving at the speed of light (300,000 km/sec)*

1 light-year = 9.46 trillion km = 9.46 10^{12} km

Light travel time from surface of Sun to us is about 8 minutes

Nucleus and its electron cloud ....





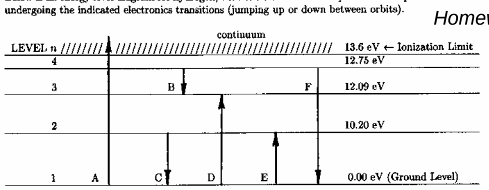
Hydrogen's Energy Diagram

Emission

Absorption

Homework 1

Below is an energy level diagram for hydrogen, with one electron. The capital letters represent individual atoms undergoing the indicated electronics transitions (jumping up or down between orbits).



$E = h\,f$ $\qquad c = \lambda\,f$

Where: E is photon energy (eV) f is photon frequency (sec^{-1} = Hz) h (Planck's constant) = 4.14×10^{-15} eV sec c (speed of light) = 3×10^{10} cm/sec 1 Å = 1×10^{-8} cm. λ (lambda) is photon wavelength (cm or Å)

Using the Hydrogen atom energy diagram given above, the equations and the constants as listed, calculate the wavelength in Angstroms (Å) of the following transitions:

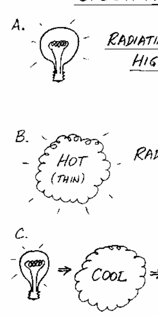
6. Transition E?____________________ Transition B?____________________

Advice: Read Appendix C.3 "Working with Units"

NATURE OF SPECTRA

"Kirchoff's Laws""

SPECTRA (KIRCHOFF'S LAWS)



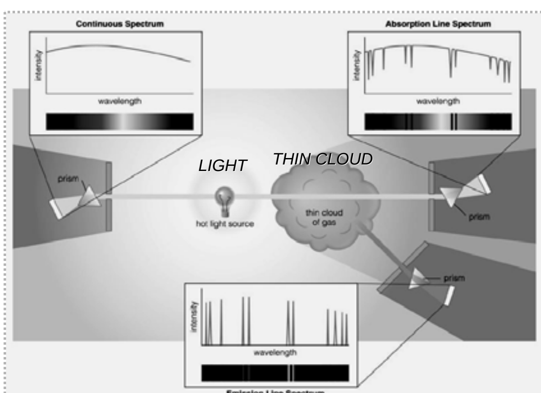
A. RADIATING SOLID, LIQUID, OR HIGH-PRESSURE GAS (OPTICALLY THICK)
⇒ CONTINUOUS SPECTRUM

B. RADIATING RARIFIED GAS (LOW DENSITY)
⇒ BRIGHT-LINE SPECTRUM (EMISSION)

Emission

C. LIGHT OF CONTINUOUS SPECTRUM VIEWED THROUGH A COOLER GAS
⇒ DARK-LINE (ABSORPTION) SPECTRUM

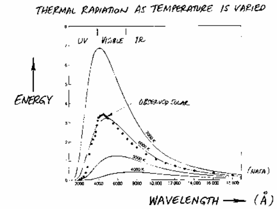
Absorption



BLACK-BODY SPECTRUM

CONTINUOUS SPECTRUM OF EMISSION BY "BLACK BODY"

PLANCK'S RADIATION LAW: BEHAVIOR OF THERMAL RADIATION AS TEMPERATURE IS VARIED



Planck

Peak emission and total energy VARY with temperature

TOTAL ENERGY EMITTED ~ $(\text{TEMPERATURE})^4$

$\mathcal{E} = \sigma T^4$ STEFAN-BOLTZMANN LAW

Stefan-Boltzmann

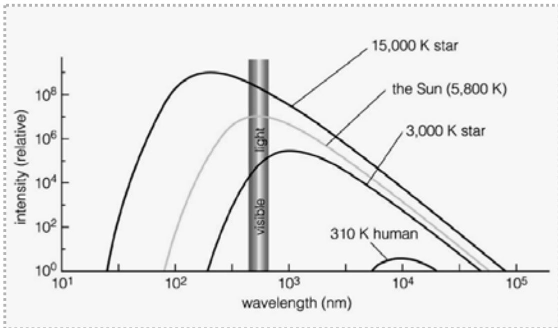
WAVELENGTH OF PEAK EMISSION ~ 1/TEMPERATURE

$\lambda_{max} \sim \frac{1}{T}$ WIEN'S LAW

Wien

{ IF INCREASE T FROM 1000 K TO 6000 K, $\mathcal{E}$ INCREASES BY FACTOR $6 \times 6 \times 6 \times 6 = 1296$! }

Spectra of Continuous Emission from Us and Stars

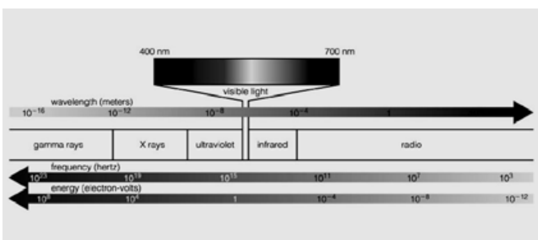


Clicker Q – EM Waves

- From *shortest to longest wavelength*, what is the correct sequence of EM radiation?

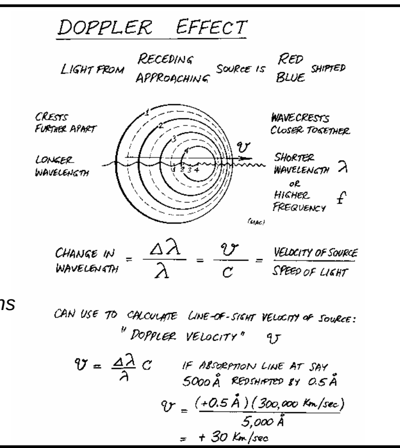
- A. gamma-rays, x-rays, UV, visible, IR, radio
- B. gamma-rays, x-rays, visible, UV, IR, radio
- C. IR, visible, UV, x-rays, gamma-rays, radio
- D. radio, IR, visible, UV, x-rays, gamma-rays

A. gamma-rays,x-rays,UV,visible,IR,radio

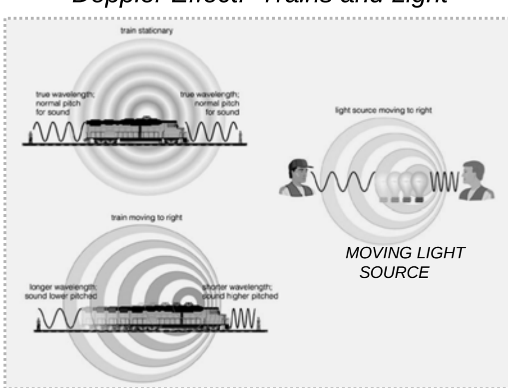


DOPPLER EFFECT

Applied to positions of spectral lines



Doppler Effect: Trains and Light



Now On to Telescopes

VLA – Scicorro, NM