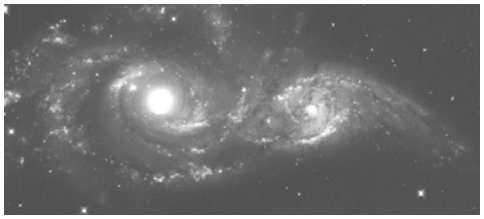
ASTR 1120 General Astronomy: Stars & Galaxies



Prof. Juri Toomre TA: Ben Brown

Lecture 2 Wed 12 Jan 05

zeus.colorado.edu/astr1120-toomre

For next two classes, read:

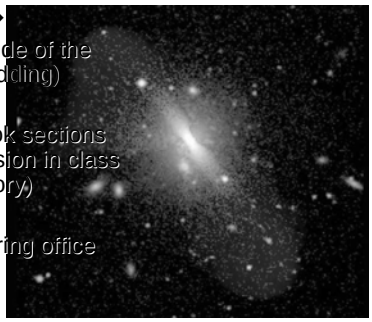
How to Succeed in this course, p. xxvi

- Chapter 1, all *(Our Place in Universe)*
- Review *Basic Astronomical* terms, p. 4
- Chapter 2, review all *(Motion of Stars, Seasons)*
- Chap 3, sec 3.5 *(Nature of Science)*
- First read of Chap 4, all *(Matter and Energy)*
- First read of Chap 6 *(Light)*

- *Register your clickers by next class*
- You can get a copy of lecture slides after class from course website (can be helpful)

How to succeed in this course

- *GOT TO PUT IN THE TIME:*
  3 credits at CU →
  6 to 9 hours outside of the classroom (no kidding)
- Read the textbook sections *BEFORE* discussion in class (secrets of memory)
- Come see us during office hours!



Come talk with us

- *Juri Toomre's* office hours: Mon, Wed after class 11:15a-noon; Thur 2:00-3:45pm in JILA Tower A-606 (phone: 303-492-7874) jtoomre@solarz.colorado.edu
- *Ben Brown's* office hours: Wed 1:00-3:00pm; Thur noon-2:00pm, in TA office, Duane E-122 (phone: 303-492-7851 or -5010) bpbrown@colorado.edu
- Or call or email us to make an appointment!

Planetarium sessions

- Three class meetings will be at Fiske Planetarium on campus

Observatory Nights

- Starting this Thur 13 Jan at 7pm, then about every 2 weeks (8 in all) – by signup
- *Sommers-Bausch Observatory* (next to Fiske): 16" and 18" telescopes
- Not mandatory, but you can get extra credit toward your homework grade

Topics for Today

- Nature of astronomy as a science
- Scientific method: we observe, hypothesize, test its predictions, maybe fix it and try again
- Light as waves
- Special colors of light associated with each element
- *Homework 1* passed out today

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 Fri 21 Jan.
- *Part B* involves completing the *`Energy Level Diagrams & Spectral Lines'* problem sheet passed out in class today. Due next Friday in class, no lates. Show how you got answers for Q 6-8 by staple-attaching worksheet.

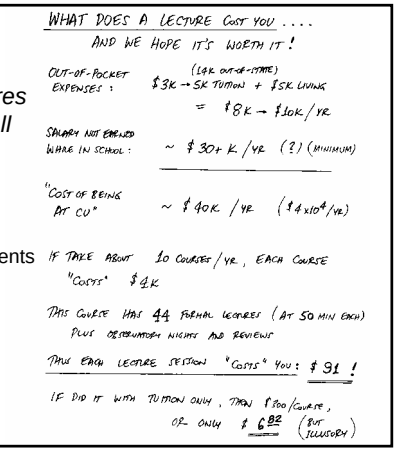
What does a lecture `cost you'?
(also a clicker tryout)

- A. About $6 each, great buy
- B. About $24 each, kind of expensive
- C. Close to $100 each, ouch!
- D. Nearly $200 each, but what a steal!
- E. Priceless, but hopefully a pleasure

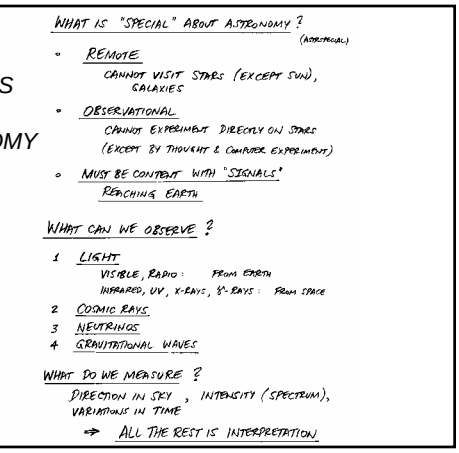
So how can we estimate the cost?

Real cost of lectures -- so use them well

Breaking a problem down to simple elements

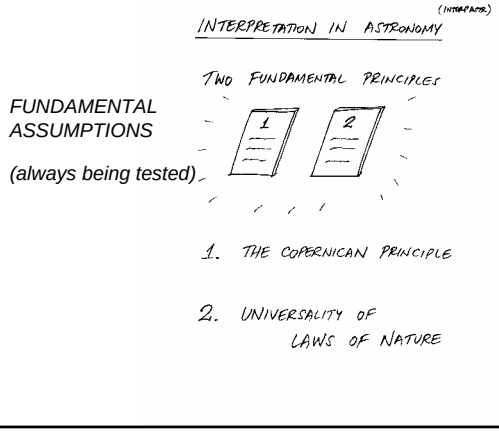


ELEMENTS OF ASTRONOMY



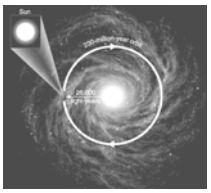
FUNDAMENTAL ASSUMPTIONS

(always being tested)



COPERNICAN PRINCIPLE

Copernicus (1473-1543)



THE COPERNICAN PRINCIPLE

Original Form:

EARTH NOT AT CENTER OF SOLAR SYSTEM

More General:

NOTHING SPECIAL ABOUT LOCATION OF ...

... EARTH IN SOLAR SYSTEM (16th - 17th C)

... SOLAR SYSTEM IN MILKY WAY GALAXY (SHAPLEY 1915-1919)

... M.W. GALAXY IN UNIVERSE (HUBBLE 1923)

Practical Implications for Astronomy:

ANYTHING OBSERVED ONCE PROBABLY OCCURS ELSEWHERE IN UNIVERSE

Thus, expect to find ...

... OTHER SUNS (STARS)

... OTHER MILKY WAYS (GALAXIES)

... OTHER PLANETARY SYSTEMS (?)

... OTHER LIFE FORMS (?)

UNIVERSALITY OF LAWS OF NATURE

SAME GENERAL LAWS APPLY EVERYWHERE IN UNIVERSE

ATOMS BEHAVE THE SAME EVERYWHERE

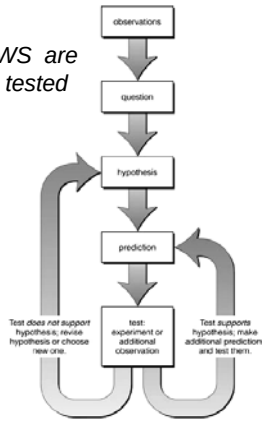
(we hope, and keep testing)

GRAVITY ACTS EVERYWHERE

Examples:

- PROTONS AND ELECTRONS ON EARTH SAME AS THOSE ON SUN
- ATOMS OF DIFFERENT ELEMENTS THE SAME EVERYWHERE
- MOON ORBITING EARTH OBEYS SAME RULES OR " = " STAR ORBITING ANOTHER STAR
- GRAVITY HOLDS TOGETHER .... STAR ... GALAXY ... CLUSTER OF GALAXIES ... ACCORDING TO ONE LAW

SCIENTIFIC LAWS are constantly being tested



FOUR TYPES OF FORCES IN NATURE

FOUR FUNDAMENTAL FORCES

(at work everywhere, we assume and test)

1. GRAVITY
   WEAKEST, BUT DOMINATES UNIVERSE
2. ELECTROMAGNETIC (EM)
3. STRONG NUCLEAR
   100 x EM, BUT ONLY IN NUCLEUS OF ATOM
4. WEAK NUCLEAR
   1/1000 x EM, ONLY IN ATOMIC NUCLEUS

ELECTRO-MAGNETIC RADIATION

(used for most deductions)

PHOTONS

(quanta – particles of light)

ELECTROMAGNETIC RADIATION (EMRAD)

γ-RAYS, X-RAYS, UV, VISIBLE, IR, MICROWAVE, RADIO

← "LIGHT" →

ACT BOTH LIKE

WAVES AND PARTICLES (PHOTONS)

PHOTONS

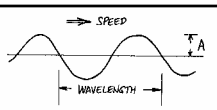
SMALLEST PACKETS ("QUANTA") OF LIGHT ENERGY

QUANTUM NATURE OF LIGHT MOST EVIDENT WHEN LIGHT INTERACTS WITH ATOMS

⇒ SPECTRAL LINES

PROPERTIES OF WAVES

WAVES



PROPERTIES:

WAVELENGTH	λ	
FREQUENCY	f	(ALSO ν)
AMPLITUDE	A	
SPEED	C	

WAVELENGTH x FREQUENCY = SPEED

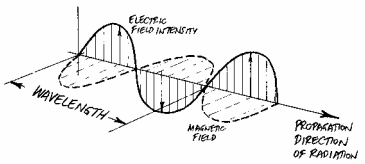
$$\lambda \times f = c$$

OTHER USEFUL PROPERTIES:

DIFFRACTION	(GRATING)
REFLECTION	(MIRROR)
REFRACTION	(PRISM, LENS)
DOPPLER SHIFT	

ELECTROMAGNETIC RADIATION AS A WAVE

E-M (LIGHT) AS WAVES



$\lambda \times f = c$

WAVELENGTH × FREQUENCY = SPEED OF "LIGHT"

$\lambda = c/f \quad , \quad f = c/\lambda$

PROPAGATION SPEED OF ALL EM WAVES IS THE SAME !

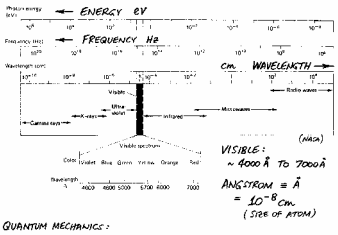
C IS A CONSTANT $\approx 300,000$ Km/sec

$= 3 \times 10^{10}$ cm/sec

Speed of light SAME for all wavelengths

ELECTROMAGNETIC SPECTRUM

E-M SPECTRUM



VISIBLE : ~ 4000 Å TO 7000 Å

ANGSTROM ≡ Å $= 10^{-8}$ cm. (SIZE OF ATOM)

Quantum Mechanics

(energy of photons varies)

QUANTUM MECHANICS :

PHOTON ENERGY = PLANCK'S CONSTANT × FREQUENCY

$E = h \times f$

HIGHER FREQUENCIES OR SHORTER WAVELENGTHS $\Rightarrow$ MORE ENERGY

(UV, X-RAYS MORE DANGEROUS !)