

ASTR 3520
Astronomical Observations and Instrumentation II: Spectroscopy
Fall 2007

Homework 1:
Due: 11 September 2007 (Tuesday in class)

Purpose:

Exercise simple concepts of light, energy, and units used in spectroscopy.

1) Photon properties

- a) What is the wavelength of the radiation given off by a 100 MHz FM broadcast ?
- b) Can this signal propagate into and through a 10 meter diameter tunnel having conducting walls? Why or why not?
- c) What is the energy of each 100 MHz photon?
- d) Consider a 10^4 Watt transmitter. How many photons are radiated per second?
- e) What is the frequency of 5500 Å light?
- f) What is the energy of each photon (in c.g.s. units)?
- g) What is the momentum (in c.g.s.) carried by each photon?
- h) Consider a hard gamma ray with an energy of 1 TeV. What is the wavelength?
- i) What is the frequency?

2) Telescopes & resolution

- a) What is the angular resolution of the 100 meter diameter Green Bank radio telescope at a frequency of 23 GHz? (If you do not know what this is, Google “Green Bank Telescope”)
- b) What is the theoretical diffraction limited resolution of our 24” telescope at $\lambda = 6000$ Å?

3) Collision rates in a gas. Consider a gas of molecular hydrogen with density $n = 10^{15}$ (this is the typical density of a proto-planetary disk) and a temperature of 100 Kelvin.

a) Using the typical size of a hydrogen atom $r = 0.5 \text{ \AA}$, and that a hydrogen molecule consists of 2 atoms, estimate the cross section, $\sigma = \pi r^2$.

b) Estimate the thermal velocity in this gas.

c) Estimate the mean time between collisions in this gas.

Hints: $V \sim (kT / m)^{1/2}$
 $R = n\sigma V$