PHY 452/562 Lasers and Modern Optics (due Tuesday Oct. 8th 2013)

Homework # 2

Problem 1. The mirrors in a Fabry-Perot interferometer have a reflection coefficient $r = 0.8944$. Determine (a) the coefficient of finesse F, (b) the half-width γ, (c) the finesse Φ.

Problem 2. A Fabry-Perot interferometer is to be used to resolve the mode structure of a He-Ne laser operating at 632.8 nm. The frequency separation between the modes is 150 MHz. The plates are separated by an air gap and have a reflectance r^2=0.999.

a) What is the coefficient of finesse of the instrument?
b) What chromatic resolving power is required?
c) What plate spacing is required?
d) What is the free spectral range of the instrument under these conditions?
e) What is the minimum resolvable wavelength interval under these conditions?

Problem 3. The separation of a certain doublet is 0.0055 nm at a wavelength of 490 nm. A variable-spaced Fabry-Perot interferometer is used to examine the doublet. At what spacing does the mth order of one component coincide with the (m+1)th order of the other?

Problem 4. Express Planck's formula for the density of energy $\rho_T(\nu)$ in a blackbody cavity in terms of the wavelength λ. Then, prove Wien's displacement law, calculating Wien's constant.

Problem 5. In a thermonuclear explosion the temperature in the fireball is momentarily 10^7K. Find the wavelength at which the radiation emitted is a maximum.

Problem 6. Using the experimental apparatus shown below, when ultraviolet light with a wavelength of 240 nm shines on a particular metal plate, electrons are emitted from plate 1, crossing the gap to plate 2 and causing a current to flow through the wire connecting the two plates. The battery voltage is gradually increased until the current in the ammeter drops to zero, at which point the battery voltage is 1.40 V.

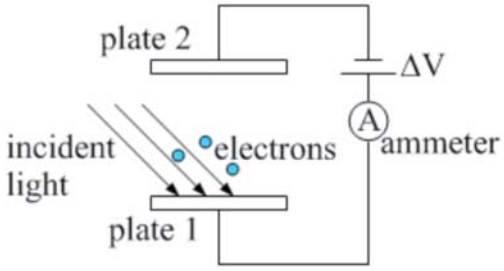
(a) What is the energy of the photons in the beam of light, in eV?

(b) What is the maximum kinetic energy of the emitted electrons, in eV?

(c) What is the work function of the metal, in eV?

(d) What is the longest wavelength that would cause electrons to be emitted, for this particular metal?

(e) Is this wavelength in the visible spectrum? If not, in what part of the spectrum is this light found?



Problem 7. A beam of x-rays with wavelength 0.2400 nm is directed toward a sample. The x-rays scatter from the electrons within the sample, imparting momentum to the electrons, which are initially at rest in the lab frame. After scattering, the x-rays are detected at various angles relative to the direction of the incoming beam using a detector that can resolve their wavelengths.

(a) What is the longest wavelength measured by the detector?

(b) At what scattering angle does this occur?

(c) For this scattering angle, what is the kinetic energy of the recoiling electrons?

(d) If the detector measures a wavelength for the scattered x-rays of 0.2412 nm, what is the x-ray scattering angle?

(e) What is the direction of travel of the recoiling electrons in this case?

Problem 8. A photon is emitted as a hydrogen atom undergoes a transition from the n = 6 state to the n = 2 state. Calculate (a) the energy, (b) the wavelength and (c) the frequency of the emitted photon.

Problem 9. (a) Find the energy of the electron in the ground state of doubly ionized lithium, which has an atomic number Z = 3. (b) Find the radius of its ground-state orbit.

Additionally, solve problem 2.1, from the Milonni book (2^{nd} edition).