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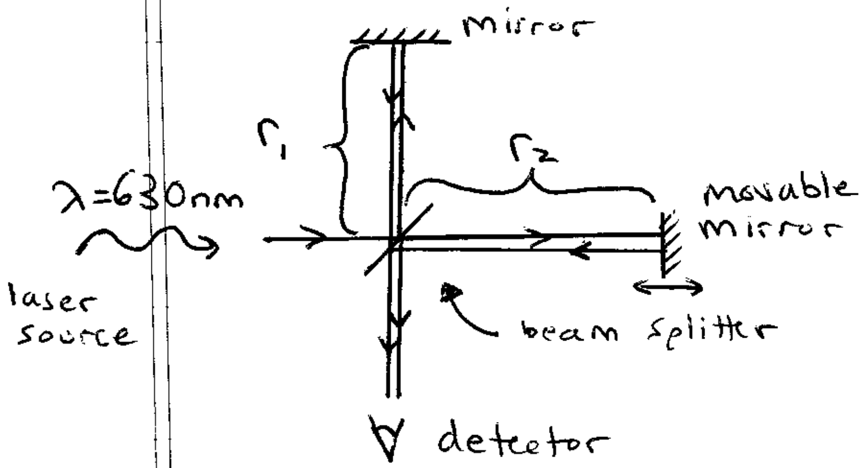
Phys 122-401

11/28/06

QUIZ 10 : Interference

In a Michelson interferometer, laser light travels (hint: back-AND-forth) down two arms after being split into two beams. If we change the length of one arm, we will see light and dark fringes appear and disappear at the detector. For the situation shown, how many dark (or light) fringes would we count if we change the length of an arm by $\Delta r = 1\text{mm}$?



path length difference $= \delta = 2\Delta r$ (back-and-forth)

for constructive interference, need $\delta = m\lambda$ where m is an integer

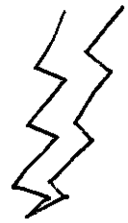
$\Rightarrow 2\Delta r = m\lambda$, and we move mirror by Δr so we count m fringes

$$m = \frac{2\Delta r}{\lambda}$$

$$= \frac{2(1\text{ mm})}{(630\text{ nm})} = \boxed{3174 \text{ fringes}}$$

Homework 10 –

Ch 27: 2, 4, 13, 26, 34, 38, 42, 44

(2) a)  $T = 10^4$ K b)  $T = 10^7$ K

Wiens Law //

$$\lambda_{max} T = 0.2898 \times 10^{-2}\ m\cdot K$$
$$\Rightarrow \lambda_{max} = \frac{0.2898 \times 10^{-2}\ m\cdot K}{T}$$

a) $\lambda_{max} = 2.898 \times 10^{-7}$ m $\boxed{UV}$ b) $\lambda_{max} = 2.898 \times 10^{-10}$ m $\boxed{\gamma\text{-rays}}$ //

(4) $E = 2500$ eV

$\lambda_{red} = 690$ nm $\lambda_{blue} = 420$ nm

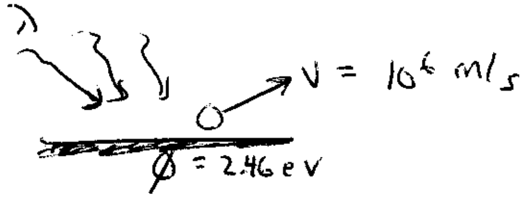
quantization of energy //

$$E = nhf = \frac{nhc}{\lambda} \Rightarrow n = \frac{E\lambda}{hc}$$

$(hc = 1240\ eV\cdot nm)$

$$\Rightarrow \begin{cases} n_{red} \simeq 1400 \text{ photons} \\ n_{blue} \simeq 850 \text{ photons} \end{cases}$$

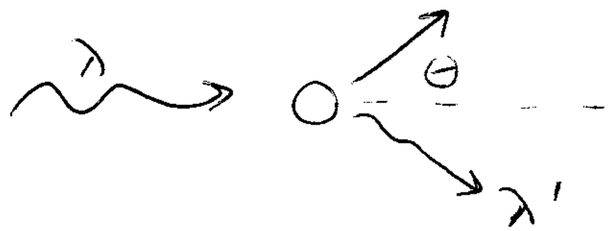
(13) photo-electric effect //



$$KE = hf - \phi$$
$$\frac{1}{2}mv^2 = \frac{hc}{\lambda} - \phi$$
$$\frac{1}{2}mv^2 + \phi = \frac{hc}{\lambda}$$
$$\lambda = \frac{hc}{\frac{1}{2}mv^2 + \phi} \Rightarrow \boxed{\lambda = 234 nm}$$

m = mass of e^- //

(26)



ompton effect

$$\Delta\lambda = \frac{h}{mc}(1-\cos\theta) \longrightarrow \text{Compton effect}$$

want to solve for θ

$$\frac{mc\,\Delta\lambda}{h} = 1-\cos\theta$$

$$\frac{mc\,\Delta\lambda}{h} - 1 = -\cos\theta$$

$$\cos\theta = 1 - \frac{mc\Delta\lambda}{h}$$

m = mass of e^-
c = speed of light
h = planck's const
$\Delta\lambda = 1.5 \times 10^{-3}$ nm

$$\Rightarrow \theta = 67.5^\circ$$

(34) de Broglie $\lambda = \frac{h}{p}$

de Broglie hypothesis

$p = mv$, classically, but near speed of light, need special relativity

$$p \rightarrow \gamma mv \equiv \frac{mv}{\sqrt{1-v^2/c^2}}$$

m = mass of proton, c = speed of light, h = planck's const

$v = 2\times10^4$ m/s $\Rightarrow p = \gamma mv \Rightarrow \lambda = \frac{h}{p} = 2\times10^{-11}$ m

$v = 2\times10^7$ m/s $\Rightarrow \lambda = 2\times10^{-14}$ m

(38) according to problem, require $\lambda = 0.075\,m$ to notice diffraction

de Broglie wavelength "

$$\lambda = h/p \Rightarrow p = h/\lambda = mv$$

$$v = \frac{h}{m\lambda} = \frac{h}{(80\,kg)(0.075\,m)} \approx \underline{\underline{10^{-34}\ \frac{m}{s}}}$$

very S L O W - - -

$$v = \frac{d}{t} \Rightarrow t = \frac{d}{v} = \frac{15\,cm}{10^{-34}\,m/s} \approx 10^{33}\,s$$

very L O N G !

much larger than age of universe!

(42) Heisenberg says: $\Delta x\, \Delta p \geq \frac{\hbar}{2} = \frac{h}{4\pi}$

Heisenberg uncertainty principle "

suppose best case $\Rightarrow \Delta x \Delta p = h/4\pi$

$m = 50\,g = 0.05\,kg$, $v = 30\ m/s \Rightarrow p = mv$

$\Delta p = 1.5 \times 10^{-3}\ kg \cdot \frac{m}{s}$

$$\Delta x = \frac{h}{4\pi \Delta p} = \underline{\underline{3.5 \times 10^{-32}}}\ m$$

for macroscopic things, we can know **both** momentum and position extremely well.

(44) quack!

"h" $\rightarrow 2\pi$ J·s

$m = 2$ Kg

$\Delta x = 1$ m

Heisenberg uncertainty principle //

$$\Delta v = \frac{\Delta p}{m} \geq \frac{\text{"}h\text{"}}{4\pi m \Delta x} = 0.25 \text{ m/s} \quad //$$

uncertainty in future position due to uncertainty in initial position and initial speed:

$$\Delta x = \Delta x_0 + \Delta v_0 t$$

$$= 1\text{ m} + (0.25 \text{ m/s})(5\text{ s})$$

$$= 2.25 \text{ m} \quad //$$