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PHY 9HC A02

Homework 3

Exercise 1: Q4M.5

$$
\begin{aligned}
I &= \frac{P}{4\pi r^2} \\
\frac{photons}{s} &= \frac{P_{sheet}}{E_{ph}} = \frac{IA}{hc/\lambda} = \frac{\lambda A}{hc}\frac{P}{4\pi r^2} \\
&= \frac{590nm * (8mm)^2 pi * 20W}{6.626 * 10{-}34j * s * 3 * 10^8 m/s * 4 * pi * (100m)^2} \\
&= 9.5 * 10^{10} \;\; photon/s
\end{aligned}
$$

Exercise 2: Q4M.8

pure wave	EEV	observe
$I_e \propto I$	if $k\lambda^3 > W, I_e \propto I$	if $f > f_s, I_e \propto I$
$t \approx \frac{w}{Id^2}$	instantly	instantly
resonance	$k\lambda^3 < W, I_e = 0$	if $f < fc, I_e = 0$
$max(KE) \propto I$	max(KE) is independent of intensity	max(KE) is independent of intensity
max(KE) may depend on frequency	if $k\lambda^3 > W, max(KE) \propto \lambda^3$	if frequency > cutoff frequency, $max(KE) \propto f$

If we discuss the EEV model qualitatively, it is similar with the observe result. However, if we want to discuss this model qualitatively, the result will be different because the energy function is different.

Exercise 3: Q4R.2

assume that the wave length of light is 590 nm

6 megapixel needs $3 * 6 * 10^6 = 1.8 * 10^7$ photon

exposure time = 5s

$\therefore 1.8 * 10^7/5 = 3.6 * 10^6$ photon/s

$$photon/s = \frac{P_{sheet}}{E_{ph}} = \frac{IA}{hc/\lambda}$$

$$I = \frac{photon/s \cdot hc}{\lambda A}$$

$$= 1.54 * 10^{-10} W/m^2$$

$0.5/1.54 * 10^{-10} = 3.23 * 10^9$

$0.5W/m^2$ is much larger that the minimum average intensity of light

Exercise 4: Q5M.5

$$\lambda = \frac{hc}{\sqrt{2kmc^2}} = \frac{1240eV \cdot nm}{2 \cdot 100eV \cdot 511000eV} = 0.0388nm$$

width $= D2sin^{-1}(\frac{\lambda}{a}) = 10 \cdot 2 \cdot \frac{0.0388\ nm}{1\ \mu m} = 7.76 * 10{-}4$ m

The width is $7.76 * 10^{-4}$ m

Exercise 5: Q5M.12

(a)

$$\lambda = \frac{hc}{K(K+2mc^2)} = \frac{1240ev}{20GeV(20GeV + 2 \cdot 511000eV)} = 6.2 * 10^{-8}$$

(b)

$$\frac{10^{15}}{6.2 * 10^{-8}} = 1.613 * 10^{22}$$

the wavelength of electrons is much smaller than the wavelength of the nucleus.

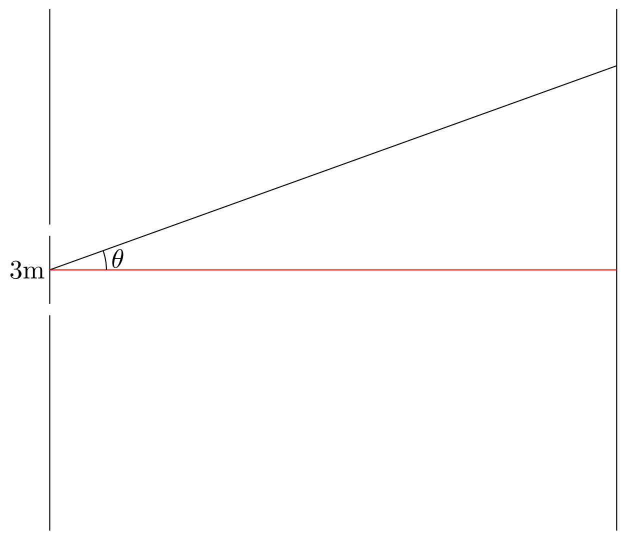
(c)

$mc^2 = 511000eV$

$K = 2.0 * 10^{10}eV$

Because K is much larger than mc^2, mc^2 can be neglected. So it does matter whether 20 GeV is the total energy or the relativistic kinetic energy.

Exercise 6: Q5R.1



$$p = mv = 0.5kg * 6m/s = 3kg \cdot m/s$$
$$\lambda = \frac{h}{p} = \frac{1}{3}\ m$$
$$d\ sin\theta = \frac{1}{2}n\lambda$$
$$sin\theta = \frac{n\lambda}{2d} = \frac{n}{18}, \quad n = 2k+1, k \in \mathbb{Z}^+$$