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Modern Physics
(2D)
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Problem 1 : Mystery Metal [10 pts]

In a particular photoelectric experiment a stopping potential of 2.10V is measured when ultraviolet light having a wavelength of 290nm is incident on the metal. Using the same setup, what will be the new stopping potential if blue light with a wavelength of 440nm is used, instead of the ultraviolet light.

Answer: 0.64V

Problem 2: Xtreme Pool ! [10 pts]

An electron moving to the left at 0.8c collides with an incoming photon moving to the right. After the collision, the electron is moving to the right at 0.6c and the scattered photon moves to the left. (a) sketch this process (b) Write down the conservation equations. (c) What was the wavelength of the incoming photon?

Answer: 2.91×10^{-12} m

QUIZ 4

(1) the stopping potential is 2.1 V $= V_0$ for wavelength $\lambda = 290$ nm

we would like to determine the stopping potential for light of wavelength $\lambda' = 440$ nm.

1st, let's determine the work function for the metal:

$$eV_0 = hf - \phi = \frac{hc}{\lambda} - \phi$$

$$\Rightarrow \quad \phi = \frac{hc}{\lambda} - eV_0 = 2.18 \text{ eV}$$

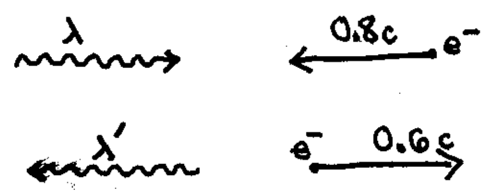
Now let's find the stopping potential for $\lambda = 440$ nm:

$$eV_0' = hf' - \phi = \frac{hc}{\lambda'} - \phi = 0.64 \text{ eV}$$

$$\Rightarrow \quad V_0' = 0.64 \text{ V}$$

(2) (a) Initially:

After collision:



(b) momentum conservation

$$\frac{h}{\lambda} - p_{e_i} = p_{e_f} - \frac{h}{\lambda'} \qquad (I)$$

OR

$$\frac{h}{\lambda} - \gamma_i m_e u_i = \gamma_f m_e u_f - \frac{h}{\lambda'} \qquad (II)$$

Energy conservation

$$\frac{hc}{\lambda} + \gamma_i m_e c^2 = \gamma_f m_e c^2 + \frac{hc}{\lambda'} \qquad (III)$$

OR

$$\frac{hc}{\lambda} + \sqrt{(p_{e_i}c)^2 + (mc^2)^2} = \frac{hc}{\lambda'} + \sqrt{(p_{e_f}c)^2 + (mc^2)^2}$$

(c) we wish to solve for the wavelength of the incoming photon, λ, so let's eliminate λ' from our system of equations, using equation (I)

$$\frac{h}{\lambda'} = p_{e_f} + p_{e_i} - \frac{h}{\lambda}$$

multiply by c, the speed of light:

$$\frac{hc}{\lambda'} = p_{e_f}c + p_{e_i}c - \frac{hc}{\lambda}$$

and substitute into (III):

$$\frac{hc}{\lambda} + \gamma_i mc^2 = \gamma_f mc^2 + p_{e_f}c + p_{e_i}c - \frac{hc}{\lambda}$$

now solve for $\frac{hc}{\lambda}$

$$\frac{2hc}{\lambda} = \gamma_f mc^2 - \gamma_i mc^2 + p_{e_f}c + p_{e_i}c$$

and then for λ:

$$\lambda = \frac{2hc}{\left[(\gamma_f - \gamma_i)mc^2 + p_{e_f}c + p_{e_i}c\right]}$$

for $u_i = 0.8c$, $\gamma_i = 1.67$ $\Rightarrow$ $p_{e_i} = 0.68$ MeV/c

$u_f = 0.6c$, $\gamma_f = 1.25$ $\quad$ $p_{e_f} = 0.38$ MeV/c

$$\Rightarrow \lambda = 2.9 \cdot 10^{-12} \text{ m}$$