Physics 211: Modern Physics

Problem Set 5: Due 5 Nov 2024

1. Relativistic Electrons

In class, when considering the accelerations of electrons in Bragg Scattering, we assumed that the electrons were non-relativistic and worked out that when accelerated through a potential difference V_0, the electrons would hit the anode with a speed $v = \beta c$ where:

$$\beta = \sqrt{2}\sqrt{\frac{eV_0}{mc^2}}.$$

Notice that this is more nicely expressed as

$$\beta = \sqrt{2}\sqrt{\frac{E}{E_0}} = \sqrt{2}\sqrt{\alpha},$$

where α is the dimensionless quantity representing the ratio of the potential energy change to the rest energy of the electron.

a. Now re-do our calculation in class, but this time, make the calculation relativistically correct. Derive an expression for β in terms of the dimensionless parameter $\alpha = \frac{eV_0}{mc^2}$, showing your reasoning as you go.

b. Using a plotting program make a plot of both the relativistic and non-relativistic β as a function of α. Each axis should be labelled and extend from 0 to 1. Comment on your plot—does your result make sense?

c. Suppose that we accelerated protons (instead of electrons) through a potential difference of 511 kV. What would β for the protons be?

2. Blackbody radiation

Taylor, problem 4.4

3. Dangerous Microwaves?

Taylor, problem 4.9

4. Why we don't use incandescent lightbulbs

Taylor, problem 4.14

5. Bragg Diffration

Taylor, problem 4.20

5. Compton Backscattered photon

Taylor, problem 4.28