PY 810

Exercises

1. Read Chadwick's paper (on web site)

2. Derive his formula (on page 696) for the maximum recoil energy of a mass m in Compton scattering using conservation of energy and momentum. Derive and use the relativistic equation

$$pc = \sqrt{T\left(T + 2mc^2\right)}$$

where p, T are the momentum and kinetic energy of the recoiling particle of rest-mass m.

Check his statements on the energy of the γ rays necessary to account for his observations.

3. Derive the formula at the bottom of page 698 for the maximum recoil velocity of a target particle in the case when the incident particle has mass M and velocity v. Compare the result with his observations.

4. The potential for an anti-neutron interacting with a nucleus has been modelled as (neglecting absorption)

$$U(r) = -V\frac{1+w(r/c)^2}{1+\exp[(r-c)/a_V]}$$

For Oxygen^{16} possible parameters are

$$V = 198Mev$$
$$c = 2.608fm$$
$$a_V = .539fm$$
$$w = -.051$$

Find the scattering length by integrating the Shroedinger equation from $r = 0$ to a position where the potential $U(r)$ is negligible and extrapolating thereafter by a straight line.

Compare to the analytic result for a square well with depth V and radius $R = c$.

5. For protons (He^3) the coherent scattering length is -.374 (.62) $\times 10^{-12}$ cm and the incoherent scattering cross section is 80 (1.2) barns. (1 barn $=10^{-24}$ cm^2). Using this information calculate a_s for these nuclei and thus the equivalent (pseudo) magnetic field experienced by a neutron travelling through a material containing 10^{22} fully polarized nuclei/cm^3 of each of these nuclei.

$$a = a_o + a_s\overrightarrow{s}\cdot\overrightarrow{I}$$

The magnetic moment of the neutron is $\mu_n = -6.03 \times 10^{-12} ev/gauss = -9.66 \times 10^{-24} ergs/gauss$

6. Define

$$f(x) \otimes g(x) = \int_{-\infty}^{\infty} f(x_1) g(x - x_1)\, dx_1$$

and show that ($\Leftrightarrow$ signifies a Fourier transform pair)

$$f(x) \otimes g(x) \Leftrightarrow F(y)\, G(y)$$
$$f(x) g(x) \Leftrightarrow \frac{1}{2\pi} \left(F(y) \otimes G(y) \right)$$

where $f(x)$ and $F(y)$ are related by

$$f(x) \Leftrightarrow F(y)$$
$$f(x) = \frac{1}{2\pi} \int_{-\infty}^{\infty} F(y)\, e^{ixy} dy$$
$$F(y) = \int_{-\infty}^{\infty} f(x)\, e^{-ixy} dx$$

Note $\delta(x) = \frac{1}{2\pi} \int_{-\infty}^{\infty} e^{\pm ixy} dy$.

This finds applications in almost all areas of physics.

7. Referring to the calculation of multiple scattering effects using matrix techniques (on the web as "moscowstucnsect1.pdf") redo the two scattering center case for scattering (instead of for a bound state as in section 1.1.2) and calculate the forward scattering length. Repeat for 3 scattering centers located at the vertices of an equilateral triangle with the origin in the center.

What is the magnitude of the additional terms due to multiple scattering.