Q.M. H.W. #11

#1 Derive the optical Theorem: $\sigma = \frac{4\pi}{k} \mathrm{Im}(f(0))$

Please give a "handwaving" explanation for how this result makes sense from a probability standpoint.

From Saxon:

Problem 9.

(a) At a center-of-mass energy of 5 MeV, the phase shifts describing the elastic scattering of a neutron by a certain nucleus have the following values:

$$\delta_0 = 32.5°, \qquad \delta_1 = 8.6°, \qquad \delta_2 = 0.4°.$$

Assuming all other phase shifts to be negligible, plot $d\sigma/d\Omega$ as a function of scattering angle. What is the total cross section σ? For simplicity take the reduced mass of the system to be that of the neutron.

(b) The same if the algebraic sign of all three phase shifts is reversed.

(c) The same if the sign of only δ_0 is reversed.

(d) Using the results of part (a), calculate the *total* number of neutrons scattered per second out of a beam of 10^{10} neutrons per cm² per sec, of cross-sectional area 2 cm², incident upon a foil containing 10^{21} nuclei per cm². How many neutrons per second would be scattered into a counter at 90° to the incident beam and subtending a solid angle of 2×10^{-5} ster-radians?

From Liboff:

14.3 Analysis of the scattering of particles of mass m and energy E from a fixed scattering center with characteristic length a finds the phase shifts

$$\delta_l = \sin^{-1}\left[\frac{(iak)^l}{\sqrt{(2l+1)l!}}\right]$$

(a) Derive a closed expression for the total cross section as a function of incident energy E.

(b) At what values of E does S-wave scattering give a good estimate of σ?

From Ohanian:

9. In the scattering of particles of energy $E = \hbar^2 k/2m$ by a nucleus, an experimenter finds a differential cross section

$$\frac{d\sigma}{d\Omega} = \frac{1}{k^2}(0.86 + 2.55 \cos\theta + 2.77\cos^2\theta)$$

(a) What partial waves are contributing to the scattering, and what are their phase shifts at the given energy?

(b) What is the total cross section?