22.54 Neutron Interactions and Applications
(Spring 2002)

Problem Set No. 2 **Due: Feb. 19, 2002**

Problem 1

(a) Consider a plane wave incident upon a spherically symmetric potential V(r) of finite range r_o. Derive the angular differential scattering cross section in the form,

$$\frac{d\sigma}{d\Omega} = |f(\theta)|^2 \qquad (1)$$

where $f(\theta)$ is the scattering amplitude (explain how this quantity is introduced into the problem).

(b) In the case of low-energy scattering where only the s-wave contribution is important (explain what this means), show how one can determine $f(\theta)$ using the given V(r).

(c) Define the scattering length a. Rewrite Eq.(1) in terms of a.

(d) Apply your results above to neutron-proton scattering where the potential is given as a spherical well, $V(r) = -V_o$ for $r < r_o$, and $V(r) = 0$ for $r > r_o$, with $V_o = 36$ Mev and $r_o = 2$ F ($1\ F = 10^{-13}$ cm). Find a, $d\sigma / d\Omega$, and the cross section σ.

(e) Comment on your results in (d). Is your value of σ in agreement with experiment? If not, describe briefly what is missing.

Problem 2

(a) Consider the kinematics of neutron elastic scattering by a nucleus with mass number A. Derive the relation $E' = \frac{1}{2} E[(1+\alpha) + (1-\alpha)\cos\theta_c]$, where E, E' are the initial and final energies of the neutron in LCS and θ_c is the scattering angle in CMCS.

(b) Find the scattering frequency $F(E \rightarrow E')$ for the case where the angular distribution of the scattered neutron in CMCS is forward biased, i.e., $P(\Omega_c) = \frac{1}{4\pi}(1 + a\cos\theta_c)$.

Comment on your result and compare it with the case where P is spherically symmetric.

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