

Physics 137B: Problem Set #10
Due: 5PM Friday April 23 in the appropriate dropbox
inside 251 LeConte (the “reading room”)

Suggested Reading for this Week:

- B&J Sections 13.3,13.4,13.6, and 13.1 (pages 590-592)

Homework Problems:

1. We will model the case of nuclear scattering as scattering off a hard sphere of radius R .

- (a) The radius R of a nucleus can be expressed as

$$R = r_0 A^{1/3}$$

where $R_0 = 1.1 \times 10^{-15}$ m and A is the mass number of the nucleus. Suppose a neutron scatters from a Gold nucleus. For what range of neutron momenta would you expect s-wave scattering to dominate?

- (b) Suppose our nucleus has a kinetic energy of 1 MeV/c. What is the scattering cross section if you assume only s-wave scattering is important?
- (c) What is the size of the p-wave ($\ell = 1$) term relative to the s-wave term calculated above?

Hint: Use B&J Eq 13.50 and Eq 13.79 and the explicit expressions for the j_ℓ and n_ℓ on page 342.

2. (taken from Liboff Problem 14.2) The scattering amplitude for a certain interaction is given by

$$f(\theta) = \frac{1}{k} \left(e^{ika} \sin ka + 3ie^{2ika} \cos \theta \right)$$

where a is the range of the potential and k is the wavenumber of the incident particle

- (a) What is the s-wave differential cross section for this interaction?
- (b) Suppose the above scattering amplitude is appropriate to neutrons incident on a species of nuclear target. Let a beam of 1.3 eV energy neutrons with current $10^{14} \text{ cm}^{-2}\text{s}^{-1}$ be incident on this target. What number of neutrons per second are scattered out of the beam into $4\pi \times 10^{-3}$ steradian about the forward direction? Take a to be $2 \times 10^{-15} \text{ m}$.
3. Use the Born approximation to calculate the differential and total cross sections for the exponential potential

$$V(r) = V_0 \exp(-\alpha r)$$

4. Use the Born approximation to calculate the differential and total cross sections for the Gaussian potential

$$V(r) = V_0 \exp(-\alpha^2 r^2)$$

5. Use B&J Eq 13.13 and 13.15 to prove Eq 13.16