

Physics 5403

Problem Set 10 – due November 20, 2009

Problem 1

Let us consider a potential energy

$$V(\vec{r}) = \begin{cases} V_0 = \text{constant}, & \text{for } r \leq R, \text{ and} \\ 0, & \text{for } r > R. \end{cases}$$

- (a) Apply the method of partial waves, find the total cross section for $|V_0| \ll E = \hbar^2 k^2 / 2m$ and $kR \ll 1$.
- (b) Suppose the energy is raised slightly. Show that the angular distribution can be expressed as

$$\frac{d\sigma}{d\Omega} = A + B \cos \theta .$$

Problem 2

Let us consider a potential energy

$$V(\vec{r}) = \begin{cases} V_0 = \text{constant}, & \text{for } r \leq a, \text{ and} \\ 0, & \text{for } r > a. \end{cases}$$

- (a) Apply the first order Born approximation and find the scattering amplitude $f_B(\vec{k}_\beta, \vec{k}_\alpha)$ for low energy scattering.
- (b) Find the total cross section.

Problem 3

A spinless particle is scattered by a weak Yukawa potential

$$V(\vec{r}) = \frac{V_0 e^{-\mu r}}{\mu r}$$

where $\mu > 0$.

- (a) Find the first-order Born amplitude (f_B).
- (b) Apply f_B and assume $|\delta_\ell| \ll 1$, find an expression for δ_ℓ in terms of a Legendre function of the second kind,

$$Q_\ell(x) = \frac{1}{2} \int_{-1}^{+1} \frac{P_\ell(x')}{x - x'} dx' .$$