PROBLEM SET 4– due Wed. 3-11

Physics 215B- Quantum Mechanics, WINTER 1998

Problem 1: Consider an experiment in which slow neutrons of momentum $\hbar k$ are scattered by a diatomic molecule. Suppose that the molecule is aligned along the y axis with atoms at $y = \pm b$, and that the neutrons are directed along $\hat{\mathbf{z}}$. Assume the atoms are infinitely heavy so they remain fixed throughout the experiment. The potential seen by the neutron can then be represented by

$$V(r) = a[\delta(y-b) + \delta(y+b)]\delta(x)\delta(z).$$

Calculate the scattering amplitude and differential cross section in the Born approximation.

Problem 1: Calculate the differential cross section for scattering from a Coulomb potential $V(r) = \alpha/r$ in the first Born approximation. (You might want to compare your answer to the exact solution, available, for example, in Baym's book.)

Problem 1: [UCSB PRELIMINARY EXAM, WINTER 1982] Calculate the differential cross section for the elastic scattering of an electron by a ground state hydrogen atom in the first Born approximation. Ignore the effects of electron spin and exchange.

PROBLEM SET 5– due Wed. 3-18

Physics 215B- Quantum Mechanics, WINTER 1998

Problem 1: Consider scattering from a hard sphere

$$\begin{aligned} V(r) &= 0 \qquad && r > a \\ V(r) &= \infty \qquad && r < a. \end{aligned} \tag{1}$$

(a) Find the phase shifts for all partial waves.
(b) Find the total cross section for low energies (ie for $ka << 1$).
(c) Find the total cross section for high energies (ie for $ka >> 1$).

Problem 2: Calculate $f_k(\theta, \phi)$ and σ in the Born approximation for scattering off a potential $V(r) = \lambda\delta(r)$.

Problem 3: Find the phase shifts for scattering of a particle of mass m off a potential $V(r) = A/r^2$. Discuss the case $2mA/\hbar^2 << 1$.

Problem 4: [UCSB PRELIMINARY EXAM, FALL 1982] A neutron and a proton are taken to have equal mass M and interact via the potential $V(r) = V_0(r)$ for $r < r_0$ and $V(r) = 0$ for $r > r_0$. Here $V_0(r) < 0$ for $r < r_0$.

(a) What is the scattering cross section due to the $l = 0$ patial wave for center of mass frame energy $E = \hbar^2 k^2/M$ in terms of the phase shift δ_0?

(b) Let the scattering wave function be $\psi(r) = u(r)/r$. By eliminating the phase shift, express the cross section at $E = 0$ and for small E in terms of the ratio $u'(r_0)/u(r_0)$.