Physics 829: Problem Set 2

Due Wednesday, April 15, 2009 at 11:59 PM

Each problem is worth 10 points unless otherwise specified

1. Consider an experiment in which slow neutrons of momentum $\hbar k$, incident along $\hat{\mathbf{z}}$, are scattered by a diatomic molecule; suppose that the two atoms of the molecule are located at $(0, b, 0)$ and $(0, -b, 0)$. Assume the atoms to be infinitely heavy so that they remain fixed throught the experiment. The potential seen by the neutron from the each atom is adequately represented by a delta function. Thus,

$$V(\mathbf{r}) = a\delta(x)\delta(z)[\delta(y-b) + \delta(y+b)]. \tag{1}$$

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

2. Shankar, problem 19.5.2.

3. (20 pts.) Shankar, problem 19.5.4.

4. Consider a potential $V = 0$ for $r > R$; $V = V_0 =$ constant for $r < R$, where V_0 may be positive or negative. Using the method of partial waves, show that if $|V_0| \ll E = \hbar^2 k^2/(2m)$, and also $kR \ll 1$ where $k = \sqrt{2mE/\hbar^2}$, the differential cross-section is isotropic and the total cross-section is given by

$$\sigma_{tot} = \frac{16\pi}{9}\frac{m^2 V_0^2 R^6}{\hbar^4}. \tag{2}$$

   Suppose the energy is increased slightly. Show that the differential scatterieng cross-section can then be written

$$\frac{d\sigma}{d\Omega} = A + B\cos\theta \tag{3}$$

   and find an approximate expression for B/A.