Physics 8.322, Spring 2003
Homework #11

Due Wednesday, May 7 by 4:00 PM in the 8.322 homework box in 4-339B.

1. For hard sphere scattering as discussed in class, numerically evaluate and graph the following quantities:
   (a) $|f(\theta)|^2$ as a function of $\theta$ for the following values of $\rho$: 0.1, 0.5, 1, 10, 25, 100
   (b) $\sigma_{\text{tot}}/(\pi R^2)$ as a function of $\rho$ for $\rho \leq 100$.

2. Sakurai: Problem 8, Chapter 7 (page 443)

3. Sakurai: Problem 9, Chapter 7 (page 444)

4. Determine the phase shift $\delta_0$ for scattering from the potential $V(r) = -V_0 e^{-r/a}$. Analyze the connection between $\delta_0$ and the spectrum of bound states for this potential in the case $l = 0$.

5. Consider the elastic scattering of fast (but nonrelativistic) electrons from an atom consisting of a point nucleus of charge $Z$ and a spherically symmetric charge distribution of atomic electrons $\rho(r)$. Show that in the first Born approximation the scattering amplitude is

   $$f(\theta) = \frac{2mZe^2}{\hbar \kappa^2} \left( 1 + \frac{4\pi}{Ze} \int_0^{\infty} r^2 dr \rho(r) \frac{\sin \kappa r}{\kappa r} \right)$$

   where $\kappa = 2k \sin \theta/2$. Compute and graph $\sigma(\theta)$ for an electron with energy 1 keV scattering from the potential

   $$\rho(r) = \begin{cases} 
   -\frac{3Ze}{4\pi\alpha_0^3}, & r \leq a_0 \\
   0, & r > a_0 
   \end{cases}$$