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 θ for the following values of ρ: 0.1, 0.5, 1, 10, 25, 100

(b) $\sigma_{\text{tot}}/(\pi R^2)$ as a function of ρ 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 δ_0 for scattering from the potential $V(r) = -V_0\, e^{-r/a}$. Analyze the connection between δ_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

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

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

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