QUANTUM MECHANICS I

PHYS 516

Problem Set # 5

Distributed: Feb. 18, 2011

Due: Feb. 25, 2011

Recall: I want a story line as well as a computation: Words - words - words — even sentences!

1. Matrix Mechanics - More discretization and Numerical Solution: Discretize the Schrödinger equation for a particle in a one-dimensional bimodal Ginzburg-Landau potential: $V(x) = \frac{1}{4}x^4 - \frac{5}{2}x^2$. Set $m = \hbar = 1$.

a. "Size" this problem appropriately. State explicitly the range $(-L, +L)$ that you are discretizing and what your step size Δ is. What is the size of the matrix you are diagonalizing. Explain why you chose these parameter values.

b. Plot the eigenfunctions with the six smallest eigenvalues.

c. Do you believe these might be good approximations to the actual eigenfunctions? Explain why (or why not).

d. Make some general remarks about the eigenvectors and their properties.

2. Hydrogen Radial Wavefunctions:

a. Plot the $3s, 3p, 3d$ hydrogen radial wavefunctions on the same graph. Size the graph so everything important shows and unimportant stuff doesn't.

b. Now plot their probability distributions.

c. What can you say about the mean value of r ($\langle r \rangle$) as the orbital angular momentum l increases?

d. Does your intuition square with Table 2^5?

3. Radial Matrix Elements: Compute

$$\langle n', l' | r | n, l \rangle = \int_0^\infty R_{n'l'}(r) \;\; r \;\; R_{n,l}(r) \; dr$$

when the quantum numbers are "saturated": $l = n-1, l' = n'-1$ and $n' = n-1$. **Be careful:** the values of R in the Condon-Shortley tables have a factor of r included from the radial volume element ($r^2 \; dr$), so integrals are $\int$ ... dr. Other tabulations do not include this factor, so the integrals are $\int$ ... $r^2 \; dr$.