Homework 4 Due October 21

1. What is the effective Bohr radius and ground state energy for:

    a. Singly ionized helium atom
    b. Positronium
    c. Two neutrons bound by gravitational field

2. At t = 0 a hydrogen atom is prepared at the state

$$\psi(r,0) = \frac{4}{(2a_B)^{3/2}}\left\{\frac{e^{-r/a_B}}{\sqrt{4\pi}} + A\frac{r}{a_B}e^{-r/a_B}\left(-iY_1^1 + Y_1^{-1} + \sqrt{7}Y_1^0\right)\right\}$$

    a. Find A
    b. If L^2 measured what are possible outcomes and corresponding probabilities?
    c. If the energy is measured what could be the lowest possible value obtained?
    d. Where is the electron most likely to be found?

3. Find energy spectrum (energy levels) for a particle of mass m moving in the region with the central potential $V(r) = \frac{A}{r^2} - \frac{B}{r}$.

4. For a hydrogen atom in state ψ_{nlm} find expectation values $\langle r \rangle$ and $\langle r^2 \rangle$.

5. Plot radial probability distributions $|R_{10}|^2, |R_{20}|^2, |R_{30}|^2, |R_{21}|^2, |R_{22}|^2, |R_{32}|^2$. Make the horizontal axis in Bohr radius units. Plot angular probability distributions (either 3D or 2D x-z plane) $|Y_0^0|^2, |Y_1^1|^2, |Y_1^0|^2, |Y_1^{-1}|^2, |Y_2^0|^2, |Y_2^1|^2, |Y_2^2|^2, |Y_3^1|^2$.