PHYS4702 Atomic, Nuclear, & Particle Physics Fall 2015 HW #5

Due at the start of class on Thursday 24 Sept 2015

(1) Using MATHEMATICA or some other program, reproduce the plots in Figure 7-5 of the textbook, that is the radial probability density distributions for the properly normalized wave functions of the three one-electron atomic states shown for $n = 1$ and $n = 2$.

(2) Consider the $n = 2$, $\ell = 1$, $m = 0$ state of the hydrogen atom. Calculate the location at which the probability density is a maximum, in units of the Bohr radius. Then calculate the expectation value $\langle r \rangle$ of the radial coordinate. Compare the two results and explain why they are different.

Note: You can use (7-29) to check your answer for $\langle r \rangle$, but do the integration to get your solution. You are welcome to use MATHEMATICA *or some other program for the integral.*

(3) In class, we discussed the "annihilation" operator $\hat{a}$ and its Hermitian conjugate $\hat{a}^\dagger$, the "creation" operator, in relation to the simple harmonic oscillator. Using the differential forms of these operators, show that operating with $\hat{a}$ on the ground state wave function gives zero, and operating with $\hat{a}^\dagger$ on the ground state wave function gives a function proportional to the first excited state wave function.