Homework Set 14

1. Consider the ground state of a hydrogen atom.

(a) Use a computer to make an accurate graph of $|\psi|^2$ versus r.

(b) Calculate the mean radius $\langle r \rangle$, and express the answer in terms of the Bohr radius.

(b) Find the radius $R_{0.5}$ such that the probability that the electron is inside this radius is 0.5. Express the answer as a fraction of the Bohr radius. Also, express the answer in cm.

2. Consider a hydrogen atom.

(a) Determine the energy in eV of a photon emitted when the electron makes a transition 2p → 1s.

(b) Determine the wavelength of the photon. In what part of the electromagnetic spectrum is this wavelength?

3. A muonic atom consists of a negative muon (mass = 105 MeV/c^2) bound to a proton.

(a) What is the binding energy? Express the answer in eV and MeV.

(b) What is the mean radius of the ground state? Express the answer in Bohr radii and in cm.

4. (a) The initial state of a hydrogen atom is

$$|\Psi(0)\rangle = \frac{1}{\sqrt{2}}|1s\rangle + \frac{1}{\sqrt{2}}|2p, m = 1\rangle.$$

Calculate the expectation value of the electron position $\vec{x}$ (a *vector*) in this state.

(b) Calculate the expectation value of the electron position $\vec{x}$ for an arbitrary time t. Show that the result undergoes simple harmonic motion.

(c) Calculate the frequency of the simple harmonic motion, in seconds.

(d) Calculate the amplitude of the simple harmonic motion, in cm.