Name(s): PHY-222 (Fall 2018), 11/07/18

Homework Assignment #6

(*Due Date*: Wed, 11/14, 04:10 pm, in class; Show all your work for full/partial credit)

6.1 *Relativistic Muon Plane Wave* (cf. Prob. 6.3 in textbook) *(2 pts.)*
A freely moving muon (mass $m_\mu c^2$=105.6 MeV) is described by the wave function $\psi_\mu(x,t)$=$A\cos(kx - 0.8t)$ where t is measured in fm/c. Calculate the muon's

(a) frequency ω (in Hz) and corresponding total energy E (in MeV);

(b) momentum in (MeV/c) and de Broglie wavelength (in fm).

6.2 *Gaussian Wavepackage and Schrödinger Equation* (cf. Prob. 6.3 in textbook) *(2 pts.)*
A localized electron at rest has a wave function $\psi(x)$=$A\exp(-a^2x^2)$ with a=0.5/nm.

(a) Use the results from class to quote it's space and momentum uncertainty.

(b) Use the static Schrödinger equation to calculate the pertinent potential, $U(x)$.

6.3 *Bound Protons in a Nucleus* (cf. Prob. 6.9 in textbook) *(5 pts.)*
The average potential experienced by protons (m_p=939 MeV/c^2) in a Ca nucleus may be schematically given by an infinite 1-D square well of length L=8 fm.

(a) Determine the proton wavefunction for the 2 lowest-lying states by solving the Schrödinger equation with boundary conditions (no need to normalize).

(b) Calculate the 2 lowest momentum values and corresponding energy levels.

(c) Calculate the wavelength of photons required to excite the proton from the ground into the first-excited state.

(d) Use the uncertainty principle to estimate the percentage uncertainty in the momentum of the ground-state proton (assume Δx=L).

(e) If the typical distance between two protons in the nucleus is 2.5 fm, compare the potential energy from electric repulsion with the energy-level spacing in the nucleus (generated by the strong nuclear force).

6.4 *Localized Electron Wavefunction* (cf. Prob. 6.29 in textbook) *(2 pts.)*
An electron is described by the wavefunction

$$\psi(x) = \begin{cases} 0 & , \quad x < 0 \\ C\mathrm{e}^{-ax}(1-\mathrm{e}^{-ax}) & , \quad x \geq 0 \end{cases} \qquad (1)$$

with a=2 nm^{-1} and an unknown constant C.

(a) Determine the normalization constant C; sketch the wave function in a graph.

(b) What is the most likely position, x_{max}, of the electron?
(*Hint: equate the derivative of* $\psi(x)$ *to zero*)