Modern Physics, EP1108

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Assignment 1

1. Calculate the radius of Hydrogen atom using uncertainty principle where the binding energy is -13.6 eV.

2. For an electron with mass 0.5 MeV, what is the required energy to achieve the wavelength of nuclear force range i.e. $\sim$ 10 fm.

3. Find out the energy expectation value for the free particle.

4. Consider a free particle described by a Gaussian wave function as given below. Find out the probability density at position $x, x + dx$, expectation value of x, p and also evaluate the amplitude for momentum space wave function using inverse Fourier transformation.

$$\Psi(x,0) = \frac{1}{(\pi\sigma_0^2)^{\frac{1}{4}}} \exp\left(-\frac{x^2}{2\sigma_0^2}\right) \exp\left(\frac{i}{\hbar} p_0 x\right) \tag{1}$$

5. Consider the following wave function at $t = 0$. Write down the wave function at a time t and plot them using Mathematica or gnupot or other plotter. Also calculate the average energy for the system. Consider the eigenvectors carry energies E_1, E_2, E_3 respectively.

$$\Psi(x,0) = \sqrt{\frac{1}{6}}\Psi_1(x) + \frac{i}{\sqrt{2}}\Psi_2(x) + \sqrt{\frac{1}{3}}\Psi_3(x) \tag{2}$$

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6. Calculate the work function of sodium, in electron volts, given the threshold wavelength is 6800 Å, and $h = 6.625 \times 10^{-34}$ Js.

7. The photoelectric threshold of a meta is 3000 Å. Find the kinetic energy of the electron ejected from it by the radiation of wavelength 1200 Å.