University of Hyderabad

School of Physics

Jan 2010 - Apr 2010 | Time : 1hr
M.Sc. II-Semester | Quantum Mechanics-I | MM : 20

Tutorial-IV : Uncertainty Principle

[1] Use the uncertainty principle to estimate the ground state energy of H- atom.

[2] Consider a particle in one dimensional square well potential

$$V(x) = \begin{cases} 0 & 0 \leq x \leq L \\ V_0 & \text{otherwise} \end{cases} \quad (1)$$

For a bound state we should have average energy less than V_0.
$< E >=< T > + < V >< V_0$
where $< T >$ and $< V >$ are the averages of the kinetic and the potential energies, respectively. If the particle is to be confined to a region of size L, use the uncertainty principle to get a rough estimate of average kinetic energy, $< T >$. Use this to find approximate minimum value of $V_0 a^2$ required for a bound state to exist.

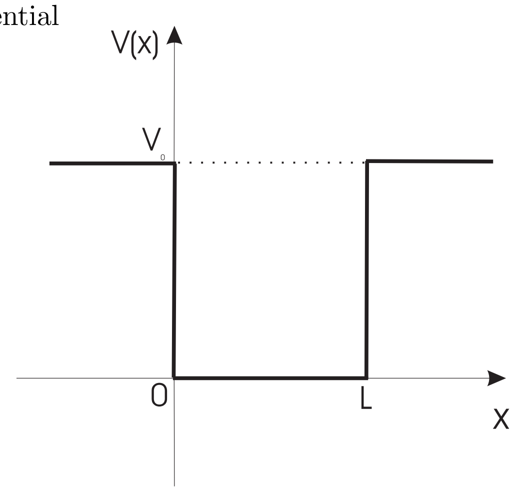

Fig. 1

[3] Use results of problem [2] to find the minimum value of V_0 required to confine an electron inside the nucleus. Take $Z = 40$, $A = 64$ and use radius of nucleus $\approx R_0 A^{1/3}$, where $R_0 = 1.2$ fm, to estimate the numerical value of the potential required to confine the electrons inside the nucleus. Compare this with the electrostatic potential energy of the electron at the surface of the nucleus.

[4] Find the minimum value of V_0 required to confine an proton inside the nucleus. Take $Z = 40$, $A = 64$ and use radius of nucleus $\approx R_0 A^{1/3}$, where $R_0 = 1.2$ fm, to estimate the numerical value of the potential required to confine the proton inside the nucleus. Compare this with the electrostatic potential energy of the electron at the surface of the nucleus and depth of the nuclear well (40 MeV).

[5] A person throws stones from height H from the ground. He aims to hit a point at a distance d on the ground. Due to the uncertainty in the initial position and momentum the aim is not accurate. Show that the minimum spread in position of the stones reaching the ground will be of the order of $\sqrt{\frac{2\hbar}{m}} \left(\frac{2H}{g}\right)^{1/4}$, where m is the mass of the stone and g is the acceleration due to gravity. Calculate the spread (a) for a stone of mass 10g and dropped from a height of 1m. (b) for a Caesium atom (A = 133) dropping a height of $H = 0.2$m.

⊘ Search more applications of (problems on) the uncertainty principle. Solve the problems and come and discuss with me.