Universität Leipzig, Fakultät für Physik und Geowissenschaften

Exercises for Experimental Physics 4 – IPSP

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Exercise Sheet 6 (Summer Term 2013)

Date of Issue to Students: May 21st 2013

Date of Submission: May 28th 2013

Submission Place: Marked mailbox next to room 302 (Linnestr. 5)
Submission Time: 11:00 a.m. at the submission day noted above

Please note: Write your name and matriculation number on EACH sheet of paper.
Only submit the calculations and results for exercise 1-3, exercise 4 will be discussed during the instruction classes.

Exercises:

1. (a) Find the energy of the ground state (n = 1) and the first two excited states of a neutron in a one-dimensional box of length $L = 1.00 \cdot 10^{-15}\, m = 1.00\, fm$ (about the diameter of an atomic nucleus). Make an energy-level diagram for this system. Calculate the wavelength of electromagnetic radiation emitted when the neutron makes a transition from (b) n = 2 to n = 1, (c) n = 3 to n = 2, and (d) n = 3 to n = 1. (7 Points)

2. Verify that the normalization constant A_0 in the ground-state harmonic-oscillator wave function $\psi(x) = A_0 e^{-ax^2}$ is given by $A_0 = (2m\omega_0/h)^{1/4}$. (Hint: You have to use the expression for a from the ground state of the harmonic oscillator.) (6 Points)

3. Using the result of Problem 2, show that for the ground state of the harmonic oscillator $\left\langle x^2 \right\rangle = \int x^2 |\psi|^2\, dx = \frac{h}{2m\omega_0} = \frac{1}{4a}$. Use this result to show that the average potential energy equals half the total energy. (7 Points)

4. The quantity $\sqrt{\langle x^2 \rangle - \langle x \rangle^2}$ is a measure of the average spread in the location of a particle. (a) Consider an electron trapped in a harmonic oscillator potential. Its lowest energy level is found to be $2.1 \cdot 10^{-4}$ eV. Calculate $\sqrt{\langle x^2 \rangle - \langle x \rangle^2}$ for this electron. (See Problems 3.) (b) Now consider an electron trapped in an infinite square-well potential. If the width of the well is equal to $\sqrt{\langle x^2 \rangle - \langle x \rangle^2}$, what would be the lowest energy level for this electron?