Universität Leipzig, Fakultät für Physik und Geowissenschaften

Exercises for Experimental Physics 4 – IPSP

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Exercise Sheet 5 (Summer Term 2013)

Date of Issue to Students: May 14^{th} 2013

Date of Submission: May 21^{st} 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. An electron remains in an excited state of the hydrogen atom (n = 2) with an average time of 10^{-8} s before it returns to state n = 1. (a) What is the expected uncertainty of the energy for state n = 2? (b) What fraction of the transition energy is this? (c) What is the wavelength and the width (in nm) of this line in the hydrogen spectrum? (7 Points)

2. Assume that you do a double slit experiment which can detect at which slit the electrons (or photons) pass. These detectors must be able to predict the y-coordinate of the particles with a precision of at least $d/2$ (d is the distance between the two slits). Use the priciple of uncertainty to show that the interference pattern is destroyed. (Hint: Show first that the angle θ between maxima and minima of the interference pattern is given by $\frac{1}{2}\frac{\lambda}{d}$.) (7 Points)

3. Assume a particle of mass m is trapped in a finite potential/quantum well with fixed wall at position $x = 0$ ($E_{pot} = \infty$ for $x < L$) and a finite high wall with $E_{pot} = E^0_{pot}$ at position $x = L$ (see figure). (a) Sketch the wave function for the first three states. (b) Write down the wave function for the ground state at position $x < 0$, $0 < x < L$ and $x > L$. (6 Points)

4. (a) Show that $\Psi(x,t) = Ae^{i(kx-\omega t)}$ is a solution of the time-dependent Schrödiger equation of a free particle with $[E_{pot}(x) = E^0_{pot}$ = constant], while $\Psi(x,t) = A\cos(kx-\omega t)$ and $\Psi(x,t) = A\sin(kx-\omega t)$ are no solutions. (b) Show that the solution in (a) fulfills energy conservation if the de-Broglie relations $\lambda = h/p$ and $\omega = E/\hbar$ are valid. Show that $\hbar\omega = \frac{\hbar^2k^2}{2m} + E^0_{pot}$.

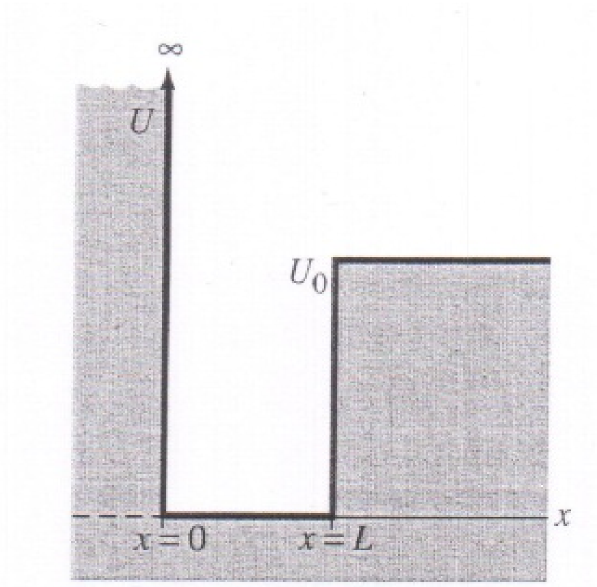

Figure 1: Exercise 3: Quantum well