Modern Physics

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Exercise 7

§ Wave-Particle Dualism & Atoms §

Problem 1: Schrödinger's equation: Infinitely deep potential well

One electron is captured within an infinitely deep and one dimensional potential well. The energy of the ground state is $E_0 = 0.1\,\mathrm{eV}$.

a) What is the width of the potential well?

b) How large is the probability to find the electron in the left third of the potential well?

c) At what energy level E the first excited state of the electron can be found?

Problem 2: Harmonic oscillator strength

A particle of mass m_0 is trapped in a potential well of the form $V = \frac{1}{2}Dx^2$. Assume that the quantum mechanical wave function in the ground state has the following form:

$$\psi_0(x,t) = A_0 \cdot \exp\left(-\frac{x^2}{a_0^2}\right) \cdot \exp\left(-\frac{iE_0 t}{\hbar}\right). \tag{2.1}$$

a) What is the frequency f of a classical particle in the potential well?

b) Write down the Schrödinger equation for a quantum mechanical particle in the potential well.

c) What is the dependence of the energy E_0 and the parameter a_0 on the force constant D and on the mass m_0?

Problem 3: X-rays and Moseley's law

The x-ray spectrum from a molybdenum ($Z = 42$) x-ray tube with $U = 35\,\mathrm{kV}$ acceleration voltage is shown in the following Figure 1:

a) Calculate the wavelengths λ of the K-α- and the K-β-lines using Moseley's law and compare them with Figure 1.

b) Calculate the cut-off wavelength λ_{cut} and compare it with the diagram.

c) At what wavelengths λ would you expect the L-α- and the L-β-lines assuming that the screening constant is $\beta = 7.4$?

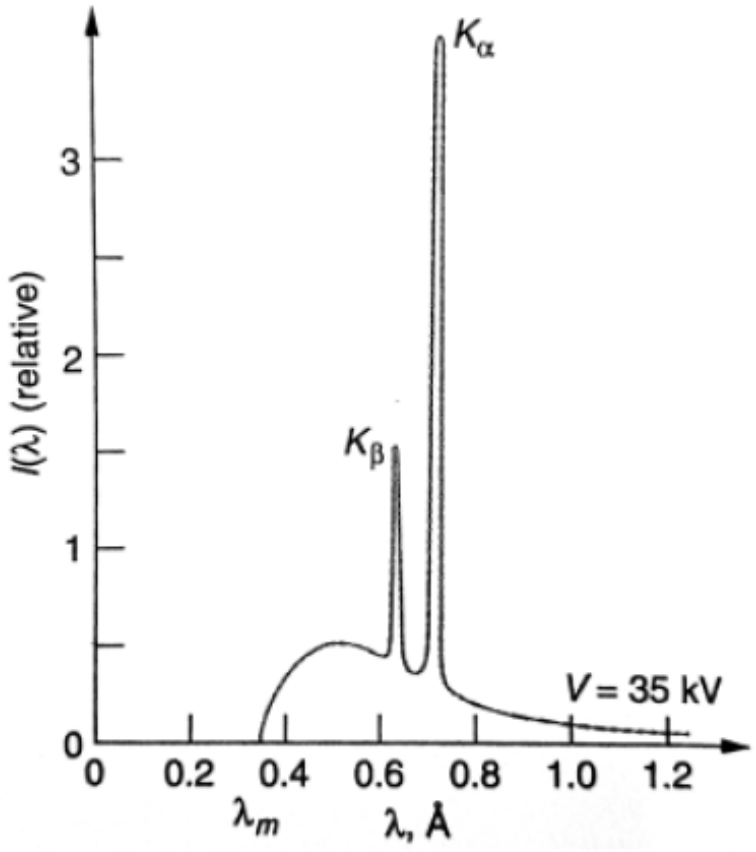

Figure 1: X-ray spectrum of molybdenum.