

DEVELOPMENT OF EXPERIMENTAL KNOWLEDGE OF FUTURE TEACHERS

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In this article, the scientific physical methodology related to the use of physical experiments in the laboratory classes of atomic physics in higher educational institutions of pedagogical direction is highlighted, and the methodology and necessity of the field is based on the application methodology for future physics pedagogues.

Introduction: The use of such software to automate and control physical experiments (as well as technical objects) defines a special place in the improvement of physical experiments in computer equipment and nanoscale objects that can perform the transmission properties of computers.

In the system of training physicists, the Department of Atomic Physics plays an important role as a logical continuation of all departments of General Physics, because this department helps in many ways to form a modern scientific and theoretical way of thinking and to clarify the optimized dualism of the methodical-digital space of understanding the unified physical picture of the universe (methodology and digitization of teaching). Therefore, the most important scientific and methodical task before the teacher is, first of all, to conduct training for the student based on reliable evidence about the simplicity and

harmony of the logical structure of atoms and nano-sized objects, the naturalness of the mathematical apparatus used in it, and its two-way connection with experience.

This type of training is carried out by performing appropriate laboratory work in the curriculum, directly familiarizing with laboratory devices related to atomic physics, obtaining results, processing experimental results, analyzing results and drawing relevant conclusions.

Laboratory work 4. Frank-Gers' experiment with mercury

The purpose of the work: to evaluate the observational measurement based on the Frank-Gers experiment with mercury-virtual development.

Let's look at a simulation program that allows us to describe the state of electrons and the wave function in the orbits of a hydrogen atom (Figure 3.2.35).

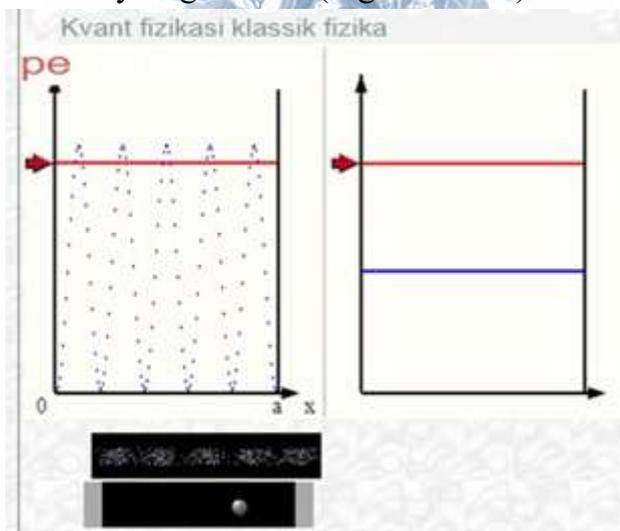


Figure 1. Motion of a particle in a potential medium of finite depth.

The created model presents the movement of a particle in a potential well of finite depth. Although the wave function is actually a mathematical abstraction, it contains reliable information about the studied object. In order to get the results of the laboratory work, the student presses the result button, assigning values to the quantum numbers n , l , m , and receives results on the screen for the entered state of the hydrogen atom in the graph of the state radius of the electron relative to the nucleus, the image of the cloud model, and the expressions for calculating the wave number and energy for these states. Performs and calculates the following tasks [29].

3 Observe the ground state of an atom in the $1s$ state, determine the quantum-mechanical interpretation and parameters.

4 Explain the quantum-mechanical parameters of the images presented in the virtual development.

5 Determine the most probable distance of an electron in the 1s state from the nucleus in a hydrogen atom and compare based on virtual development.

6 Calculate the constant coefficients S and S1 for the excited 2s state of the atom.

7 Determine the most probable distance of the electron in the 2s state from the nucleus in a hydrogen atom and compare based on virtual development.

8 Determine the most probable distance of the electron from the nucleus in the 3rd level states in the hydrogen atom and compare based on virtual development.

9 How many quantum number states are there for level 3? Determine the quantum numbers and wave function states for the states.

10 How many quantum number states are there for level 4? Determine the quantum numbers and wave function states for the states.

11 Define quantum numbers and wave function states for states.

12 Explain quantum numbers and their characteristics based on images in virtual development.

13 Explain the parameters of the state based on the parameters of the s-, p-, d- and f-states in virtual development.

14 Calculate state energies based on the value of quantum numbers in the 1st, 2nd, 3rd and 4th levels.

15 Determine the most probable distance of an electron in the 2r and 3d states from the nucleus in a hydrogen atom.

16 Create and fill in a table with the levels and orbitals of the 1st, 2nd, 3rd, and 4th electronic levels, their designation, energy distribution, and quantum numbers.

17 - complete the table of values of the radial wave function.

- fill in the table of values of the functions of the θ and φ angle-dependent part of the wave function (see Appendix 3) and make a graph. These functions describe the position of electrons in atomic orbitals and plot a graph of this position.

Table 1.

Functions of the angular part of the wave function

State and wave function $\Psi_{n,l,m}$	$\theta_{l,m}$	$Y_{l,m}$

$1s^0 \rightarrow \Psi_{1,0,0}$	$\sqrt{2/7}$	$\frac{1}{\sqrt{4\pi}}$
$2s^0 \rightarrow \Psi_{2,0,0}$	$\sqrt{\frac{3\pi}{2}}$	$\frac{1}{\sqrt{4\pi}}$
$2p^0 \rightarrow \Psi_{2,1,0}$	$\sqrt{\frac{3\pi}{2}} \sin^2 \theta$	$\sqrt{\frac{3}{4\pi}} \sin^2 \theta$
$2p \rightarrow \Psi_{2,1,1}$	$\sqrt{\frac{3}{2\pi}} \cos^2 \theta$	$\sqrt{\frac{3}{4\pi}} \cos^2 \theta$
$3s^0 \rightarrow \Psi_{3,0,0}$	$\frac{3\pi}{2}$	$\frac{15}{\sqrt{4\pi}}$
$3p^0 \rightarrow \Psi_{3,1,0}$	$\pm \sqrt{\frac{1}{3}}(5\sin^3 \theta - 3\sin \theta \cos^2 \theta)$	$\sqrt{\frac{7}{16\pi}}(5\sin^3 \theta - 3\sin \theta \cos^2 \theta) e^{i\varphi}$
$3p^1 \rightarrow \Psi_{3,1,1}$	$\pm \sqrt{\frac{1}{3}}(5\cos^3 \theta - 3\cos \theta \sin^2 \theta)$	$\sqrt{\frac{7}{16\pi}}(5\cos^3 \theta - 3\cos \theta \sin^2 \theta) e^{i\varphi}$
$3d^0 \rightarrow \Psi_{3,2,0}$	$\sqrt{\frac{7\pi}{4}}(3\sin^2 \theta - 1)$	$\sqrt{\frac{15}{16\pi}}(3\sin^2 \theta - 1)$
$3d^1 \rightarrow \Psi_{3,2,1}$	$6\pi \sin^2 \theta \cos^2 \theta$	$\sqrt{\frac{15}{16\pi}} \sin^2 \theta \cos^2 \theta e^{i\varphi}$
$3d^2 \rightarrow \Psi_{3,2,2}$	$\frac{3\pi}{2}(\cos^4 \theta)$	$\frac{7}{16\pi}(\cos^4 \theta) e^{-i\varphi}$
$4s^0 \rightarrow \Psi_{4,0,0}$	$\frac{17}{2}$	$\frac{1}{\sqrt{4\pi}}$

$4p^1 \rightarrow \Psi_{4,1,1}$	$\pm \sqrt{\frac{13}{12}} (5 \cos^3 \theta - 3 \cos^2 \theta) (5 \cos^3 \theta - 2 \cos^2 \theta)$	$\pm \sqrt{\frac{35}{32}} ((5 \cos^3 \theta - 3 \cos^2 \theta) (5 \cos^3 \theta - 2 \cos^2 \theta)) e^{-i\varphi}$
$4d^0 \rightarrow \Psi_{4,2,0}$	$(\pm \sqrt{\frac{\pi}{2}} (3 \sin^2 \theta - 1) (\sqrt{\frac{1}{8\pi}} (3 \sin^2 \theta - 1)))$	$(\pm \sqrt{\frac{7\pi}{2}} (3 \sin^2 \theta - 1) (\sqrt{\frac{5}{16\pi}} (3 \sin^2 \theta - 1)))$
$4d^1 \rightarrow \Psi_{4,2,1}$	$\pm 2 (5 \sin^3 \theta - 2 \sin^2 \theta) (5 \cos^2 \theta - 2 \cos^2 \theta)$	$\frac{35}{32} (5 \sin^3 \theta - 2 \sin^2 \theta) (5 \cos^2 \theta - 2 \cos^2 \theta) e^{i\varphi}$
$4d^2 \rightarrow \Psi_{4,2,2}$	$\pm \sqrt{\frac{7}{5}} (5 \cos^3 \theta - 2 \cos^2 \theta)$	$\frac{7}{8} (5 \cos^3 \theta - 2 \cos^2 \theta) e^{i\varphi}$
$4f^3 \rightarrow \Psi_{4,3,3}$	$\sqrt{\frac{14}{\pi}} (5 \cos^3 \theta - 2 \cos^2 \theta)$	$\frac{35}{32} (5 \cos^3 \theta - 2 \cos^2 \theta) e^{i\varphi}$
$4f \rightarrow \Psi_{4,3,0}$	$\sqrt{\frac{1}{3}} (\sin^2 \theta (5 \cos^3 \theta - 1))$	$\frac{7}{8} (\sin^2 \theta (5 \cos^3 \theta - 1)) e^{i\varphi}$

The introduction of virtual development on the topic "The state of electrons in atomic orbits" into educational practice plays a fundamental role in the development of the professional competence of future personnel in the field of physics and in their scientific interpretation of the elements of quantum mechanics, and creates a basis for improving the scientific outlook of students. The created development will help students to interpret the following ideas:

- to understand the evolution of atomic models as an electron cloud model, i.e., a system consisting of an electron cloud in certain models corresponding to discrete values of the energy generated by the interaction of the nucleus and electrons;

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- to study the movement of microparticles through probabilistic-statistical laws with the help of the uncertainty relationship, and interpret them as the appearance of an electronic cloud of certain forms;

- instead of expressions such as "microparticle wave", understanding the wave of quantum objects - electron, proton, atom, etc. as a wave of matter;

- to show that probabilistic laws are more important than dynamical laws based on a broader explanation of how electronic states in an atom are determined by probabilistic-statistical laws;

- development of a method of computer modeling of electron states in an atom;

- development of a methodology for creating a virtual development and introducing it into educational practice, which allows observing electronic states in an atom,

- in order to introduce a system of real assessment of students' knowledge of "Atomic Physics" by simplifying the online testing system, taking into account the student's potential and dividing the test into three levels of complexity.

The Schrödinger equation, which forms the foundation of quantum mechanics, and its application in explaining the structure of hydrogen atoms is an educational tool that creates a foundation for enriching students' quantum-mechanical imagination.

By applying this modeled development to the educational process, it was intended to direct students to scientific research in physics by developing their quantum imagination and preparing them to perform experiments. Application of the created program to the educational process creates the following opportunities in education:

- To introduce students in detail to the Schrödinger equation and its application to the explanation of the structure of the hydrogen atom;

- Creating a complete idea of the mathematical apparatus of quantum mechanics in students;

- Applying the Schrödinger equation to the motion of a particle in a centrally-symmetric field, explaining quantum numbers and their meaning to students.

The conducted researches confirm the effectiveness of teaching the laboratory exercises on "Atomic Physics" by elucidating the quantum-mechanical models of the atomic structure and introducing the above possibilities into education.

As a result of conducted surveys, observations, and lesson analysis, students of higher education institutions today think about the structure of atoms and nanotechnologies based on the Rutherford-Bohr model of the atom, and this situation leads to limitations in the process of studying quantum-mechanical parameters, the "cloud model" of the atom. This

shows the necessity of using a modeled method in illuminating the atomic structure with the help of software tools aimed at expanding the student's scientific worldview, intellectual potential, and creative abilities in laboratory sessions. For this purpose, a modeled development called "Explanation of the state of electrons in atomic orbits" was recommended for the educational process. This development is an educational tool that illuminates the concept of the Schrödinger equation and the wave function in explaining the quantum-mechanical laws of the atom, and in explaining the structure of hydrogen atoms within the framework of quantum mechanics, creates a foundation for enriching students' quantum imagination.

$$\varphi = -27,2 \text{ В.}$$

In conclusion: Levels, criteria and indicators of the formation of the ability to solve professional problems based on physical knowledge and skills are determined. As a professional integrative skill, the structure and composition of the ability to solve professional problems based on physical knowledge and skills is revealed. The skill set includes a content component (physical knowledge needed to solve professional problems) and a procedural component (physical skills needed to solve professional problems). The skill includes three personal skills: the ability to solve problems of preventive, diagnostic and therapeutic activities based on physical knowledge and skills.

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