



## IMPROVING THE METHODOLOGY OF PHYSICS TEACHING BASED ON NON-STANDARD TASKS

(Demonstrating the Connection between Molecular Physics and Holography)

1. *Doverov Hasan Abdusamadovich*
2. *Karimova Gulchehra Jo'rabekovna*  
*gulikarimova158@gmail.com*

*Master's students, Methodology of Teaching Exact and Natural Sciences (Physics and Astronomy), UZPSTU*

### ABSTRACT

This article examines the methodological foundations of teaching physics through non-standard thinking and a problem-based approach. The scientific essence of molecular physics and holography, their interrelationship through wave nature, interference, and energy transfer processes are analyzed. The application of holographic methods in molecular research and the possibilities of three-dimensional modeling are explored. Practical recommendations based on problem-based learning, an integrative approach, virtual laboratories, and the STEAM methodology are developed. The results confirm that this approach effectively develops students' analytical thinking, spatial reasoning, and scientific inquiry skills.

**Keywords:** non-standard tasks, physics teaching methodology, molecular physics, holography, interference, problem-based learning, STEAM approach, integrative education, laser, quantum effects.

### INTRODUCTION

The primary goal of the modern education system is to develop independent thinking, scientific analysis, and creative approaches in students and learners. Physics plays a particularly important role in achieving this goal, as it fosters logical reasoning through the observation, analysis, and explanation of natural phenomena. For this reason, organizing physics education on the basis of non-standard thinking has become an essential need.

At the higher education level, methodological approaches based on non-standard thinking develop students' ability to analyze and find independent solutions rather than simply memorizing ready-made answers. For instance, instead of focusing on a simple experiment or formula during class, it is more productive to assign tasks such as analyzing a real-life situation related to that formula or explaining how a result changes



under different conditions. Such methods strengthen students' skills in inquiry, experimentation, and logical reasoning.

In secondary schools as well, a non-standard thinking-oriented approach increases students' interest in the subject. Instead of providing ready-made concepts, the teacher poses questions such as "why?", "how?", and "what if that were not the case?" Through these questions, students learn to connect phenomena with their own experience and develop the habit of creative analysis. For example, questions like "If the Earth's gravitational force changed, how would people's daily lives be affected?" encourage students to think non-standardly.

The main advantages of teaching physics through non-standard approaches are:

1. Developing analytical and creative thinking skills in students and learners.
2. Increasing activity and motivation during the learning process.
3. Enabling the use of interactive, experimental, and problem-based teaching methods.
4. Revealing the integral connection of physics with everyday life.

### **1. The Necessity of Non-Standard Thinking in Physics Education**

The modern education system requires students and learners not only to acquire ready-made information but to learn to conduct independent inquiry, analyze, and find new solutions in problematic situations. Therefore, fostering non-standard thinking in the process of physics teaching is considered an important pedagogical task. Physics itself is inherently based on experiment, observation, and analysis. However, in traditional teaching, students tend to memorize ready-made formulas and laws without analyzing their logical foundations. The non-standard approach, on the other hand, encourages students to seek answers by relying on their own observations and asking "why?" and "how?"

For example, in molecular physics, explaining the simple question "Why does the volume of a substance increase when temperature rises?" through non-standard analysis — by examining the kinetic energy of molecules, vibration frequency, and intermolecular forces — develops deep analytical thinking in students. Such approaches not only consolidate knowledge but also strengthen students' scientific worldview and their ability to draw independent conclusions. This defines the central role of non-standard thinking in the modern methodology of physics teaching.

### **2. Scientific Essence and Interconnection of Molecular Physics and Holography**

**Molecular physics** is the branch that studies the structure of matter, intermolecular forces, kinetic energy, and heat exchange processes. This field explains the



macroscopic state of matter in connection with the microscopic motion of molecules. As E.B. Khujanov states in his textbook 'Molecular Physics and Thermodynamics': "The objects around us differ from one another in their ability to maintain shape, temperature, heat capacity, compressibility, color, and many other properties. The molecular physics and thermodynamics section of the general physics course examines issues related to matter consisting of very small particles (atoms, molecules, ions), their continuous random thermal motion, and their mutual interaction. Ideas about the atomic structure of matter have existed since ancient times. Two thousand years ago, ancient Greek philosophers stated that everything in the world is made of atoms. This idea has been confirmed and developed in various forms by many researchers over the centuries."

**Holography** is a technology based on the phenomena of interference and diffraction of light waves, through which a three-dimensional spatial image of an object is produced. Holography (from Greek — complete writing) is a special method of recording and reconstructing a complete field using an interference pattern. This method is based on the laws of interference and diffraction. This new method of recording and reconstructing the spatial image of objects was invented in 1947 by the British physicist D. Gabor, who was awarded the Nobel Prize in 1971. In the early years after holography was invented, it did not receive sufficient attention. The main reason was that it was not possible to create a sharp interference pattern using light waves from heated sources. However, after the emergence of highly monochromatic rays — laser beams — a dramatic breakthrough occurred in the practical application of this method.

Several fundamental connections exist between these two fields:

### 2.1. Commonality of Wave Nature

Molecular physics analyzes the vibration, rotation, and energy-level transitions of atoms and molecules in terms of their wave nature. Holography is also based on the phase and amplitude properties of waves. Therefore, both are scientifically close to each other through wave-optical phenomena. For example, imagine molecular vibration as melodies played on the various instruments of a large orchestra. Each molecule "sings" at its own frequency, and the vibration energy resembles the pitch of a note. Holography is like a "light symphony recorder" that simultaneously captures all the sounds coming from that orchestra: it reconstructs the entire scene in 3D through phase-amplitude changes in light waves. The similarity lies in the fact that both molecular vibration and holographic recording are based on changes in wave phase and



energy — in other words, both "read wave music."

## 2.2. Interference and Energy Transfer Processes

The vibrational energies of molecules can produce interference in mutual collisions. In holography, interference occurs between light waves. This similarity can serve as an effective model for explaining complex quantum and optical processes to students. For example, inside stars, energy quanta are transferred through atomic collisions. When some molecules absorb energy, their vibrational modes can interfere with each other: strong vibration resembles constructive interference, weak vibration resembles destructive interference. In holography as well, a laser beam is split into two waves, and phase information is recorded through their constructive and destructive interference. Creative conclusion: molecules inside a star create a "micro-hologram," while the laser demonstrates this process at a macro scale.

## 2.3. Application of Holographic Methods in Molecular Research

In modern physics and biophysics, X-ray holography, neutron holography, and electron holography are used to determine the internal structure of molecules. These methods allow researchers to study the spatial arrangement of atoms within a molecule, bond angles, and the symmetry of the crystal lattice. For example, through holographic X-ray diffraction, the arrangement of atoms in a crystal lattice is measured with extraordinary precision. Imagine that inside a crystal, each atom leaves its own "light shadow." When light (X-ray) scatters from the crystal lattice, the diverse arrangement of atoms produces interference patterns. These patterns are recorded as a hologram. A computer then reconstructs the hologram to display in 3D: the precise coordinates of atoms inside the crystal, lattice symmetry, defect locations, and spatial density. Creative analogy: this is like standing in a dark room and creating a complete model of the furniture inside using only shadows — except here, the shadows are produced by light quanta.

## 2.4. Three-Dimensional Modeling

Presenting molecular models through holographic images enhances students' abstract thinking, spatial reasoning, and visualization skills. This is especially helpful for secondary school students to more easily understand difficult topics such as molecular structure, thermal motion, or phase transitions.

## 3. Non-Standard Approaches and Methodological Recommendations in the Teaching Process



The following methodological approaches yield effective results when teaching physics based on non-standard thinking at both higher education and secondary school levels:

### **1. Problem-Based Learning**

During the lesson, the teacher poses a problematic question rather than presenting a ready-made formula. Questions such as "What state would matter transition to if molecular motion stopped?" or "What is required for a hologram to form?" encourage students to inquire and explore.

### **2. Integrative Approach**

Analyzing aspects of physics related to molecular physics, optics, quantum mechanics, and information technologies together fosters an interdisciplinary worldview in students. For instance, visually presenting information about molecules through holography enables the integration of optics with molecular physics.

### **3. Virtual and Holographic Laboratories**

In today's digital age, presenting the spatial structure of molecules through 3D simulations and holographic applications (such as HoloLens, Virtual Physics Lab) allows students to observe the processes being studied in a realistic way. This method helps students feel as though they are conducting their own experiments.

### **4. Creative Assignments and Project Work**

Assigning creative tasks such as "a holographic model of molecules" or "an optical analogue of molecular vibration" teaches students research skills, analytical thinking, and academic writing culture.

### **5. STEAM Approach (Science, Technology, Engineering, Art, Mathematics)**

By integrating physics lessons with art (graphics, design) and technology, the learning process becomes more engaging, interactive, and creative for students. For example, a student can build their own holographic molecular model and present it in 3D format.

## **4. Impact of Molecular Physics and Holography Integration on Students**

Experiments and observations show that through the integration of these two fields, students develop:

- deeper spatial reasoning about physical processes;
- logical thinking and an analytical approach;
- the ability to visualize abstract concepts in a real context;
- increased interest in sciences and a spirit of creative inquiry;
- competencies in independent learning and scientific project design.

This methodology creates great opportunities for teaching difficult physics topics in



secondary schools (such as gas laws, molecular kinetics, thermal motion, and light interference) in an easy and visual manner.

### **The Connection between Molecular Physics and Holography**

There is a direct scientific relationship between molecular physics and holography. Their common feature is that both are based on the processes of interaction between light waves and matter (molecules). The main directions of this connection are presented below.

#### **a) Interaction between Light and Molecules**

Molecular physics studies the optical properties of matter, such as its absorption, transmission, and reflection of light. Holography uses exactly these phenomena to record the interference of light waves. The medium in which the hologram is recorded — for example, a photopolymer or crystal material — greatly affects the clarity and stability of the hologram depending on its molecular structure.

#### **b) Effect of Molecular Structure on Hologram Quality**

If the molecules within the material being used for hologram recording are arranged in an orderly manner, the interference pattern of the laser beams forms clearly. However, if the molecules are disordered or in a state of vibration, the clarity of the hologram decreases and the image becomes blurry. Therefore, hologram quality is directly related to the arrangement and mobility of molecules.

#### **c) The Role of Holography in Molecular Research**

Today, holographic microscopy is being used to study the motion, shape, and structure of molecules in 3D format. This technology can detect even the smallest changes at the molecular level and is widely used in biology and nanotechnology.

#### **d) Quantum and Molecular Holography**

Quantum effects observed in molecular physics also play an important role in holography, as it records the phase and amplitude of light waves. Quantum holography methods are used to study the electron density, energy states, or photochemical processes of molecules. This approach makes it possible to observe quantum-level changes occurring inside molecules.

## **CONCLUSION**

In conclusion, implementing methodological approaches based on non-standard thinking in the physics teaching process is not merely a change in teaching style — it is an enrichment of educational content with new ideas. Such a system broadens the scientific worldview of students and learners and serves to shape them as inquisitive,



deep-thinking individuals. It should be noted that a number of initiatives have also been carried out in Uzbekistan regarding the methodology of physics teaching in secondary schools, academic lyceums, vocational colleges, and higher educational institutions. Overall, molecular physics forms the theoretical foundation of holography, while holography serves as a practical tool for demonstrating and analyzing molecular processes. Thus, these two sciences complement each other: molecular physics studies the internal optical properties of matter, while holography displays them in spatial form.

### REFERENCES

1. Ganiev A.G. Physics (Part III): Optics. Atomic and Nuclear Physics. Textbook. Tashkent, 2018. "Muharrir" Publishing House.
2. Khujanov E.B. Methodology of Teaching Specialized Subjects / Textbook. Tashkent: "ZUXRO BARAKA BIZNES", 2025. 331 p.
3. Khujanov E.B. Molecular Physics and Thermodynamics. Textbook. Tashkent: "ZUXRO BARAKA BIZNES" Publishing House, 2025. 328 p.
4. O'lmasova M.Kh. Physics. Optics, Atomic and Nuclear Physics. (Book 3) Textbook for academic lyceums and vocational colleges. "Cho'lpon" Publishing House, Tashkent, 2010.
5. [www.bilimdon.uz](http://www.bilimdon.uz). Website of the Ministry of Higher and Secondary Specialized Education of the Republic of Uzbekistan.