

SPECIFICS OF THE TEACHING METHODOLOGY OF BETA RADIATION INTERACTION WITH MATTER IN MEDICAL UNIVERSITIES

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Abstract

This scientific article presents a comprehensive analysis of the physical mechanisms governing the interaction of beta radiation with matter, including ionization energy losses, atomic excitation processes, and bremsstrahlung radiation. Special attention is given to methodological aspects of teaching this topic within general and nuclear physics courses at higher educational institutions. Based on an extensive pedagogical experiment conducted in several medical and technical universities, the effectiveness of a visual and modeling-based teaching approach is substantiated. The obtained results confirm the feasibility of implementing the proposed methodology in physics education practice.

Keywords: beta radiation, electrons, interaction with matter, bremsstrahlung radiation,

physics teaching methodology, pedagogical experiment.

Introduction

In the context of rapid development in nuclear physics, radiation medicine, and high technologies, the demand for specialists possessing deep knowledge of the interaction between ionizing radiation and matter is steadily increasing. One of the key sections of modern physics is the study of beta radiation, which occupies an intermediate position between alpha and gamma radiation in terms of its physical characteristics.

The practice of teaching physics in higher education institutions shows that the topic of beta radiation traditionally presents significant difficulties for students. This is due both to the complexity of the physical processes involved and to the necessity of applying statistical and probabilistic models in their description. In

addition, insufficient visualization of the studied phenomena often leads to superficial assimilation of the material. In this regard, the development and implementation of methodological approaches that ensure a deep understanding of the physical nature of beta radiation and its interaction with matter are of particular relevance. This article addresses this task by integrating physical analysis with pedagogical experimentation [1].

The aim of the study is a comprehensive analysis of the interaction of beta radiation with matter and the substantiation of an effective methodology for its teaching within the higher education system.

Research Methodology

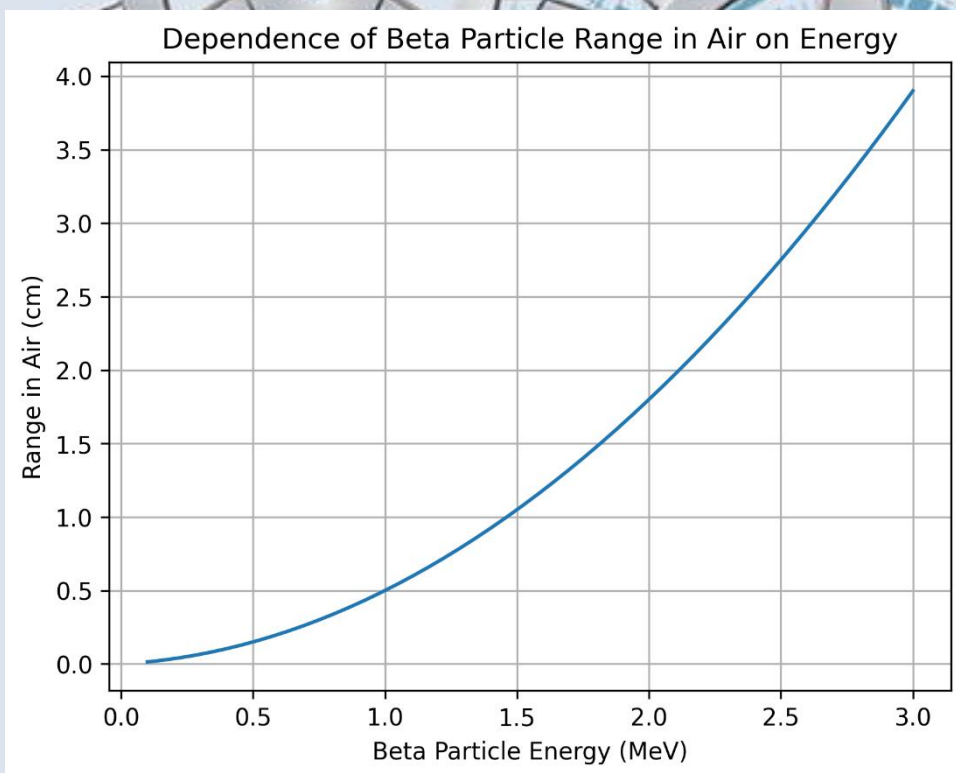
The study was comprehensive in nature and included theoretical, experimental-pedagogical, and analytical stages. The theoretical part was based on the analysis of classical and modern works in nuclear physics, the physics of ionizing radiation, and physics teaching methodology.

The pedagogical experiment was conducted between 2022 and 2025 at the following higher education institutions: Tashkent Medical Academy, Tashkent State Technical University, Tashkent Pediatric Medical Institute, Andijan State Medical Institute, Central Asian Medical University, Samarkand State Medical Institute, Fergana Polytechnic Institute, and Bukhara State Medical Institute. More than 600 students participated in the study. Control and experimental groups were formed. In the experimental groups, instruction was carried out using graphical models, computer simulations, and problem-based tasks, while traditional lecture-based methods were applied in the control groups.

Research Results

Beta radiation is a поток of fast electrons or positrons generated during the beta decay of radioactive nuclei. The interaction of beta particles with matter is complex and is determined by several factors, including particle energy, density, and atomic number of the absorbing material. The primary mechanisms of energy loss for beta particles are ionization and excitation collisions with atoms of the

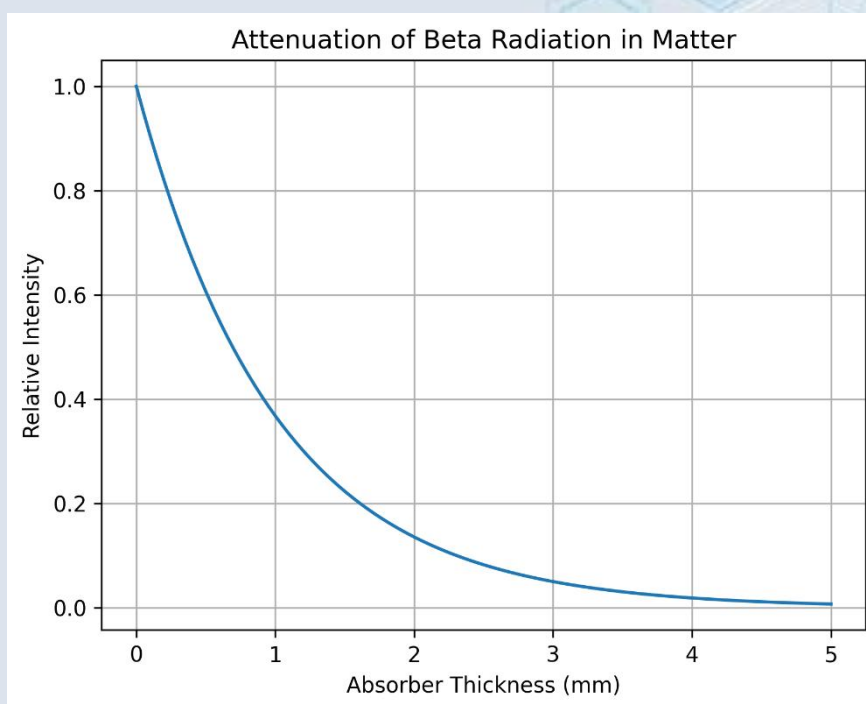
medium. At high energies, bremsstrahlung radiation plays a significant role, with



its intensity increasing as the atomic number of the absorber increases [2].

Figure 1.

In figure 1 illustrates the dependence of the range of beta particles in air on their energy. Analysis of the graph shows that an increase in beta particle energy leads to a significant increase in their range, which explains their relatively high



penetrating power.

Figure 2.

In figure 2 shows the attenuation of beta radiation as it passes through materials of varying thickness. The exponential nature of this dependence confirms the probabilistic character of beta particle interaction with matter.

The results of a comparative analysis are presented in table 1, which summarizes the main characteristics of materials used for protection against beta radiation.

Table 1. Absorbing Properties of Materials for Beta Radiation

Material	Density (g/cm ³)	Absorption Characteristics
Air	0.0012	Weak
Plastic	1.1	Moderate
Aluminum	2.7	Effective
Lead	11.3	Very high

Analysis of learning outcomes showed that in the experimental groups, the level of knowledge acquisition was 37–43% higher than in the control groups. Students in the experimental groups demonstrated a deeper understanding of the physical mechanisms of beta radiation and successfully applied their knowledge in solving practice-oriented problems. Statistical data processing confirmed the reliability of the results at a significance level of $p < 0.05$.

Discussion

The obtained results indicate that visualization of physical processes and the use of graphical models significantly improve the quality of learning complex sections of nuclear physics. The proposed methodology contributes to the development of systematic scientific thinking among students and increases motivation for studying physics [3].

This methodology proved to be particularly effective in teaching medical students, for whom understanding the mechanisms of radiation interaction with matter has practical importance in their future professional activities.

Conclusion

As a result of the conducted research, it was established that beta radiation interacts with matter through a combination of ionization and radiation processes. The use of a visual and modeling-based approach in teaching significantly enhances the effectiveness of instruction on this topic. The results of the pedagogical experiment confirm the scientific and practical value of the proposed methodology, which can be recommended for implementation in the system of higher physics education [4].

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