NOVATEUR PUBLICATIONS
INTERNATIONAL JOURNAL OF INNOVATIONS IN ENGINEERING RESEARCH AND TECHNOLOGY
[IJIERT] ISSN : 2394-3696 Website: ijiert.org
VOLUME 8, ISSUE 10, Oct. -2021

LATEST ACHIEVEMENTS OF ELEMENTARY PARTICLE PHYSICS AND THE STATE OF ITS TEACHING IN PEDAGOGICAL UNIVERSITIES

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ABSTRACT

The article discusses the achievements in elementary particle physics, teaching problems of elementary particle physics in pedagogical universities and ways to solve them.

Keywords: higher education, theory, practice, elementary particle, hadron, baryon, meson, lepton, strangeness, charmless, hypercharge, isospin, quark, fundamental interactions.

INTRODUCTION

Teaching elementary particle physics means studying the structure of the Universe, acquaintance with its constituent parts and a deep understanding of the physical processes occurring in this area. The question of what constitutes the basis of the Universe, that is, how all creatures around us are arranged, has occupied the minds of people since ancient times.

Greek philosophers were the first to try to answer this question. Some have argued that the Universe consists of four elements - air, water, earth and fire (for example, Anaximenes 585-525 BC, ancient Greek philosopher), while others put forward a different opinion that the Universe consists of the smallest indivisible “atom”s that have no structure (for example, Democritus 460-360 BC, ancient Greek philosopher) [1].

According to the modern model, the structure of the Universe, its composition consists of matter, not only consisting of elementary particles, but and dark matter, dark energy and gravitational waves that fill the Universe. Thus, when we say "elementary particle", we mean, not only elementary particles that we know, but also dark matter, dark energy and gravitational waves, because they are components of our Universe.

DISCUSSION

It is known that physics is the basis of scientific and technological progress achieved by mankind. From ancient times to the end of the 18th century, if this science has gone its way of development as part of philosophy, since the beginning of the 19th century, as an independent subject, it serves to unravel the secrets of nature and on their basis, to develop of society, to improve human life.

During the long development, the nature of research in this area has also changed over time. Initially, innovations, discoveries and inventions in physics were introduced and created by individual intellectuals, later certain desired achievements began to be achieved as a result of long-term research groups of scientists focused on solving some specific problems. Thus, from the second half of the twentieth century, such research centers began to form and function for the study of problems in particles physics as well. Such international scientific centers and organizations have appeared, such as Fermi Lab (USA), DESI (Germany), CERN (Switzerland), ESA (European Space Agency), etc.

In these scientific centers physics, mainly elementary particle physics, has made great developments over the past 30–35 years.

Examples of these advances include the theory of particle physics, unified theories, neutrino physics, non-acceleratory astroparticles physics, the study of new forms of matter, the construction of new generation accelerators, the study of the properties of cosmic rays, etc. [3].

These changes have greatly expanded our worldview in physics and have certainly become an area of interest for professionals, especially, the younger generation.

The achievements and planned experiments in the field of elementary particle physics in the World, the planned research work in this area must be constantly reflected in our higher educational system.

At present, the teaching of elementary particle physics in our higher educational system, especially in higher pedagogical universities is not meet to modern requirements.

The Elementary particle physics section is taught as a part of the General Physics course (Atomic, nuclear and elementary particle physics) at the undergraduate level in higher higher pedagogical universities, with a total of 16 hours of lectures and practical training. We think that this time is not enough to master the physics of elementary particles.

We can say the following about the literature presented in the standard program of general physics:

- Literature recommended for theoretical materials was written many years ago and does not include the latest developments in particles physics;
- Literature for practical training, even in Russian higher education system, does not include issues related to the explanation and analysis of the quark composition of particles, the processes that occur with quantum numbers such as L - lepton, B - baryon, S - strangeness, C - charmness;
- No questions or assignments to determine the level of mastering for students.

It can be seen that the knowledge gained as a result of the short presentation of theoretical information in a short period of time and the lack of practical exercises to strengthen it is not consolidated and the mastering efficiency of the Elementary particle physics section remains low.

RESULTS

In order to overcome the above shortcomings, new theoretical and practical training manual "General Physics. Fundamentals of Elementary Particle Physics" was created [4].

The theoretical part of this manual contains the latest achievements of this section, from points of view of historical development stages of elementary particle physics.

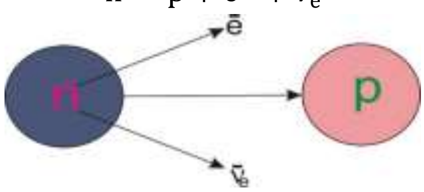
The manual covers the history of the development of elementary particle physics and the concept of elementary particles, information about elementary particles, fundamental interactions, classification and characteristics of particles, basic concepts in particle physics, fundamental particles classes, strange particles, charmed particles, symmetry conception in particle physics, interactions between particles, quark structure of hadrons, modern views on the structure of matter.

Classification of elementary particles for practical exercises, conservation of B-baryon charge, L-lepton charge, conservation laws of S-, C-quantum numbers also widely were considered, Understanding of the Gell-Mann-Nishidjima relationship $q = T_3 + \frac{Y}{2}$, hypercharge calculation $Y = B + S + C$, determination of quark composition of particles, particles with b-, t-quarks found and the problems of calculating the hypercharge $Y = B + S + C + B' + T'$ on them were introduced as well, where $B' -$ is the quantum numbers of beauty and $T' -$is the quantum numbers of reality.

Here, we show decisions of some problems on conservation laws:

1 – problem: Prove that this process is alloved by the baryon number conservation law.

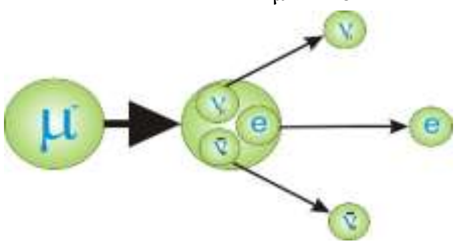
$$\mathrm{n} \rightarrow \mathrm{p} + \mathrm{e}^{-} + \bar{\nu}_{\mathrm{e}}$$



Decision: Baryon number for the left part for this reaction is equal $B = +1$. Baryon number of the proton also equals $B = +1$, electron and electron antineutrino are leptons and they have no baryon numbers. Therefore, we have $+1 \rightarrow +1 + (0) + (0)$. And this process is allowed according the baryon number (charge) conservation law. Note that we can consider this process also according the lepton number (charge) conservation law also. For the left part of this process $L_e = 0$, for the right part we can define as $L_e = 1 + (-1) = 0$. Therefore, this process is allowed according baryon and lepton conservation laws. Besides that, neutron is heavier than the sum of masses of proton, electron and electron neutrino, and heavy particle can decades to light particles.

2 – promlem: Prove that the next process is allowed according to the lepton number (chagre) conservation law.

$$\mu^- \rightarrow e^- + \nu_\mu + \bar{\nu}_e$$



Decision: For the left part of this process the lepton number (charge) is equal $L_{left} = L_\mu = +1$. For the right side also equals $L_{right} = L_\mu = +1$. For the first generation leptons we define $L_{left} = L_e = 0$, and also $L_{right} = L_e = +1 - 1 = 0$. Therefore, the lepton number (charge) conservation law is performed. In this reaction the energy conservation law also is performed as well, because the mass of μ—meson is heavier than sum mass of final particles.

3 - problem: According what interactions can occur next processes?

1. $\Sigma^+ \rightarrow \pi^+ + n$
2. $\Sigma^0 \rightarrow \Lambda + \gamma$
3. $\Sigma^0 \rightarrow \Lambda + e^- + \bar{\nu}_e$

4 – problem: Show the quark structure of K^+ - meson, and Λ^0, Ω^- hyperons.

5 – problem: define the quark structure of π^+, K^- and K^0 mesons.

6 – problem: Define the strangness S, hypercharge Y and tipe of neytral particle with $T_z = +\frac{1}{2}$ and $B = +1$.

To determine the level of mastery of theoretical and practical materials, questions and test assignments on 4 levels of difficulty are also included, which in turn allows students to independently assess their knowledge.

1. Explain the law of conservation of baryon charge (number).

A. The baryon charge (number) remains unchanged in any process with particles. In all types of interactions, this law is enforced

B. The law of conservation of baryon charge (number) was introduced to explain the absolute stability of the proton, which is the lightest baryon. A baryon should not form if it decomposes. But such fragmentation is not observed at all

C. The baryon charge is the 3rd projection of isospin - T_3, S - the odd quantum number, and C - the charm quantum numbers together with the charm quantum numbers

D. The sum of the baryon charge, S - the odd quantum number, and C - the charm quantum number is called the hypercharge

2. Explain the law of conservation of lepton charge (number).

A. In any process involving particles, the lepton charge (number) remains unchanged. In all types of interactions, this law is enforced

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B. The law of conservation of lepton charge (number) was introduced to explain the absolute stability of the electron, which is the lightest lepton. If it decomposes, lepton should not be formed. But such fragmentation is not observed at all

C. Lepton charge (number) is stored separately for each generation (family) of leptons

D. In any process with particles, the lepton charge (number) remains unchanged. In all types of interactions, this law is enforced. The law of conservation of lepton charge (number) was introduced to explain the absolute stability of the electron, which is the lightest lepton. If it decomposes, lepton should not be formed. But such fragmentation is not observed at all. Lepton charge (number) is stored separately for each generation (family) of leptons

3. In what interactions is the odd quantum number stored?

A. Stored in strong and electromagnetic interactions

B. Stored in electromagnetic and weak interactions

C. Stored in all interactions

D. Only stored in electromagnetic interaction

4. Identify the types of interactions in the following reactions.

1. $K^- + {}^4_2He \rightarrow {}^3_2\mathrm{He} + \Lambda + \pi^-$ 2. ${}^2_1\mathrm{H} + {}^2_1\mathrm{H} \rightarrow {}^4_2\mathrm{He} + \pi^0$

3. $p + {}^4_2\mathrm{He} \rightarrow {}^3_2\mathrm{He} + {}^2_1H$ 4. ${}^3_2\mathrm{He} + {}^3_1\mathrm{H} \rightarrow {}^4_2\mathrm{He} + {}^2_1\mathrm{H}$

A. 1,3,4 – strong, 2 – electromagnetic

B. 1,3 – strong, 4 – weak, 2 – electromagnetic

C. 1,3,4 – weak, 2 – electromagnetic

D. 1,3 – strong, 2,4 – electromagnetic

5. Pair with features of fundamental interactions.

1	Strong interaction	A	It is a universal interaction. All particles are involved in this effect. This interaction is the weakest of the remaining interactions.
2	Electromagnetic interaction	B	This interaction is inherent in almost all particles. The processes that take place under this influence are much slower. The $\beta-$ fission of atomic nuclei is an example of a weak interaction.
3	Weak interaction	C	The particles involved in this interaction are called hadrons. This interaction keeps protons and neutrons in the nucleus, or quarks bind by this force to form hadrons.
4	Gravitational interactions	D	In this interaction, mainly charged particles are involved. But neutral particles can also participate in this effect because they have their own structure.

Answers:	1-	2 -	3 -	4 -

6. Divide the given particles into groups and write the corresponding numbers correctly in the "numbers" section of the table.

№	Particle name	№	Particle name	Groups	Numbers
1	Electron	6	μ-meson	Hadrons	
2	Proton	7	Hyperon		
3	Neutron	8	τ-neutrino	Leptons	
4	π -meson	9	Neutrino		
5	K - meson	10	Positron		

CONCLUSION

The Elementary particle physics section of General physics differs from the rest sections that it is interesting, complex, modern, and requires a high level of imagination to study. Adequate provision of new materials to students of this section, covering modern achievements, will help students to understand the innovations in this field and master them independently. It is recommended to use the newly improved structure and content of theoretical and practical training, its teaching methods and textbooks in order to acquire in-depth and solid knowledge of the Elementary particle physics section in higher pedagogical universities.

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