OPPORTUNITIES FOR THE FORMATION OF MODERN KNOWLEDGE OF THE "LARGE HADRON COLLIDER" IN THE TEACHING OF ATOMIC NUCLEUS AND ELEMENTARY PARTICLE PHYSICS

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ABSTRACT

This article describes the possibilities for students to develop modern knowledge and skills about a large hadron collider - a device that accelerates charged elementary particles. It also provides information on the future prospects of a large hadron collider.

Keywords: Elementary particles, accelerators, large hadron collider, detector, learning technology, knowledge, skills and competencies.

INTRODUCTION, LITERATURE REVIEW AND DISCUSSION

The main part of a large hadron collider (KAK) is the elementary particle accelerator. Charged particles move in an electric field and receive large amounts of energy. A magnetic field is used to control their movement. For strong acceleration of particles, they are forced to pass through the acceleration field many times. So they move around the circle. The faster the particles move, the harder it is to control them, even with the strongest magnets. Therefore, the acceleration channel will consist of a large ring tunnel. The word “collider” (derived from the English word “collide”) means that in this channel the flow of two particles of different charges to the same energy is accelerated at the same time and then they are directed towards each other. When they collide, an almost quiescent "energy condensation" is formed, in which new particles appear. Six detectors are used in the KAK to study these new particles. Each of them consists of many electronic devices.

The KAK is truly the largest device ever created by mankind. It is located on the border of Switzerland and France at a depth of about 100 m above the Earth's surface. The length of the ring on which it is placed is 26.7 km. 1624 superconducting electromagnets are used to focus and hold the flow of particles. Due to the use of the superconducting mode, a current of 10,000 Amperes flows in the electromagnetic windings. The magnets operate at a temperature of -2710S achieved using liquid helium. The energy consumption when the collider is running is 180 million watts. Many countries participated in the construction of the KAK, which cost 4 billion euros. A natural question arises? What is the purpose of such a costly, large device, or why is it needed? To answer this question, we need to take a brief look at the history and current state of development of elementary particle physics.

Generally, "elementary" particles are particles smaller than atoms and molecules. In the early twentieth century, it became clear that atoms were made up of heavy nuclei and electrons held around them by electric forces. It was later discovered by physicists that nuclei are made up of protons and neutrons, and that they combine due to strong interactions. For this reason, they and similar particles are called "hadrons" (from the ancient Greek - "adro" - "strong"). This word is included in the name of KAK; thus, the "hadron collider" is a device in which particles involved in strong interactions collide.

This is not the end of the journey into "matter." In the 1960s, it was confirmed that protons, neutrons, and other hadrons themselves were composed of even smaller particles, quarks. More than 5,000 hadrons are now known, all of which are composed of six types (or, as physicists call them, “aromatic”) quarks. Physicists define these aromas with the first letters of their Latin names: u ("up"), d ("down"), s ("strange"), c ("leather"), b ("bottom") and t ("top"). ”). It can be seen that as it penetrated further into the microworld, physicists were also affected by emotions in naming particles. That is why romantic terms have appeared in physics, for example, "open quark" - "beautiful quark". Similarly, six types ("aromas") of particles that do not interact strongly are noted. They were called leptons (from the ancient Greek - "leptos" - "light"). One of the leptons is an electron we are all familiar with. The others are three types of muon, tau-lepton, and neutrino (electron neutrino, muon neutrino, tau-lepton neutrino).

Thus, the universe around us appears to be composed of quarks and leptons. Clearly, enumerating the facts in such a way does not give a complete picture of the enormous amount of work done to make them so. To clarify perceptions of these works, we refer to the scale of the events studied. The size of atoms and molecules ranges from one-tenth to several tens of nanometers (nano - one billionth of a meter). They are involved in chemical reactions. This releases several tens of volts of energy for each molecule (one electronvolt is the energy received by an accelerating electron under a voltage of 1 volt). It is precisely this magnitude that has been accepted for use as a unit of energy in microworld physics. Protons and neutrons have a size of one millionth of a nanometer, and the energy released in nuclear reactions is millions of electron volts. The size of quarks and leptons is less than a millionth of a proton radius, and the energy in the revolutions of quarks is thousands and millions of times greater than in nuclear reactions! If we look closely at this sequence of dimensions and energies, we see an important point: the smaller the object under study, the higher energy processes have to be used to study it. This explains exactly the need to use accelerators. In the twentieth century, a number of accelerators were built to conduct such scientific research, increasing in their capacity and size. Exactly KAK is the most powerful of them. As a result of the collision of two hadrons (proton and antiproton), 14 TeV (tera electronvolts), ie 14 trillion electronvolts of energy, is released in KAK. This energy is much larger than the "normal" energy in microworld processes. For example, in thermonuclear fusion reactions that provide energy to the Sun, almost a million times less energy is released from each participating proton!

As a result of careful analysis of all observed phenomena and collection of all relevant data, physicists have developed a theoretical model called a standard model (SM) that can well explain all processes. In this model, the whole universe is made up of "material particles" - quarks and leptons, and "particles" that interact. "Carrier particles" include photons ("light particles"), gluons (from English "glue", these particles "fasten" the quarks inside the hadrons to each other) and weakly interacting bosons. All particles move in a vacuum, despite its name (Latin for "vacuum" - "space"), in fact, a vacuum is an active physical environment in which energy is exchanged with particles. The most remarkable importance of the standard model is its never-breaking symmetry (preservation) feature (e.g., the aroma of quarks and the number of types of leptons are not the same!). The fact is that it is this symmetry that ensures that SM hypotheses and experimental results overlap with great accuracy. For example, based on the symmetry of electromagnetic and weak interactions, theorists had predicted all the properties of intermediate vector bosons until they were discovered experimentally in 1983.

Moreover, without the symmetries present in SM, all theoretical calculations lose their meaning. In other words, a violation of the symmetry of the SM “building” leads to its complete collapse. But the property of symmetry raises one of the main problems - the question of the nature of the mass of all elementary particles. The problem is that for SM to function properly, all the particles present must not have their own masses. Observations show that they have a mass. How can these two be linked to each other? It turns out that this problem can only be solved by adding a special field called the Higgs field. This area is part of the vacuum in the SM. “Massless” quarks, leptons, and other particles move in a vacuum, “stick” to a Higgs field particle, and become massive. Only those particles that do not interact with the Higgs field remain massless (photons and gluons).

Theorists, discussing the possible state of the structure of the Universe at smaller distances, have identified a number of realistic directions in the search for innovations in the field of "non-standard" physics. These are: the search for the unique nature of all interactions, the search for symmetries between particles of matter and the particles that carry interactions, the study of gravitational interactions in the microcosm, and the study of the nature of space-time. So far, we do not have experimental information on which of our perceptions of the Universe is one of the most effective ways of development. Physicists hope to obtain such experimental data from KAK.

In addition, experiments on the collision of heavy nuclei can also be conducted in the KAK. The data from such experiments can serve as a basis for the development of "energy of the XXII century", which is more powerful and safer than the energy of fusion.

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