Volume 4, Issue 4(17), 2023

Journal of Physics and Technology Education

https://phys-tech.jdpu.uz/

ONLINE ELECTRONIK JOURNAL

“Fizika va texnologik ta’lim” jurnali

Журнал “Физико-технологического образование”

“Journal of Physics and Technology Education”

Indexed By:

Publihed By:
https://phys-tech.jdpu.uz/
Jizzakh State Pedagogical University, Uzbekistan

Nashr kuni: 2023-12-30

MUNDARIJA / CONTENTS / СОДЕРЖАНИЕ

STAGES OF DEVELOPMENT OF THE SCIENCE OF PARTICLE PHYSICS

***Abduvasiyev Sardor Baxrom O`g`li*[1], *Quvvatova Charos Farxodovna*[2]**

[1]*Teacher of the department of physics and teaching methods,*

[2]*3rd grade student of physics and astronomy*

Jizzakh State Pedagogical University,Uzbekistan

e-mail: sabduvasiyev@mail.ru

***Annotatsiya**: Ushbu maqolada zarralar fizikasi fani va bu fanning rivojlanishidagi asosiy voqealar bayon etilgan.*

***Kalit so`zlar:** Kvant mehanikasi, tezlashtirgichlar, Pion, Myuon, atomning standart modeli, positron, kata adron kollayer.*

***Abstract:** This article describes the science of particle physics and the main events in the development of this science.*

***Key words:** Quantum mechanics, accelerators, pion, muon, standard model of atom, positron, large hadron collider.*

The history of particle physics is a fascinating journey that spans several centuries. Here are some key milestones and developments in the field:

1. Discovery of the Electron (Late 19th Century): In the late 19th century, experiments conducted by J.J. Thomson and his team led to the discovery of the electron. Thomson's experiments with cathode rays demonstrated that these rays were made up of tiny, negatively charged particles called electrons. This discovery laid the foundation for understanding the structure of atoms.

2. Rutherford's Nuclear Model (Early 20th Century): Ernest Rutherford conducted the famous gold foil experiment in 1911, where he directed alpha particles at a thin gold foil. The unexpected deflection of some alpha particles led Rutherford to propose a model of the atom with a small, positively charged nucleus at the center and electrons orbiting around it. This model revolutionized our understanding of atomic structure.

3. Discovery of the Proton and Neutron (Early 20th Century): In the early 20th century, scientists such as Ernest Rutherford, James Chadwick, and others discovered the proton and neutron, the two main particles found in atomic nuclei. Rutherford's experiments with alpha particles led to the identification of the

positively charged proton, while Chadwick's experiments revealed the presence of the neutral neutron.

4. Development of Quantum Mechanics (Early 20th Century): Quantum mechanics, developed by physicists such as Max Planck, Albert Einstein, Niels Bohr, and Erwin Schrödinger, provided a new framework for understanding the behavior of particles at the atomic and subatomic level. Quantum mechanics introduced the concept of wave-particle duality, where particles can exhibit both particle-like and wave-like properties.

5. Discovery of the Positron (1932): The positron, the antiparticle of the electron, was discovered by Carl Anderson in 1932. Anderson observed the positron in cosmic ray experiments and confirmed the existence of antimatter.

6. The Birth of Particle Accelerators (20th Century): The development of particle accelerators, such as the cyclotron and later the synchrotron, allowed scientists to accelerate charged particles to high energies. This enabled the study of particle interactions and the creation of new particles through collisions.

7. Discovery of the Pion (1947): The pion, the first meson to be discovered, was identified by Cecil Powell and his team in 1947. The discovery of the pion provided evidence for the existence of a new class of particles called mesons, which played a significant role in the study of particle interactions.

8. Development of the Standard Model (1960s-1970s): The Standard Model of particle physics, formulated in the 1960s and 1970s, is a theoretical framework that describes the fundamental particles and their interactions. It incorporates the electromagnetic, weak, and strong nuclear forces. The discovery of the Higgs boson in 2012 at the Large Hadron Collider (LHC) in CERN was a major milestone in validating the predictions of the Standard Model.

9. Advancements in High-Energy Particle Physics: Over the years, particle physics experiments have become increasingly complex and powerful. Particle accelerators, such as the Large Hadron Collider (LHC), have reached higher energies, allowing scientists to probe smaller scales and study rare particle interactions. These experiments continue to refine our understanding of the fundamental constituents of matter and the nature of the universe.

The field of particle physics has undergone remarkable progress, leading to groundbreaking discoveries and advancements in our understanding of the fundamental building blocks of matter and the forces that govern them. It remains an active area of research with ongoing efforts to explore new frontiers and unravel the mysteries of the universe.

Here are some further details about the history of particle physics:

10. Discovery of Quarks (1960s-1970s): In the 1960s and 1970s, the theory of quantum chromodynamics (QCD) was developed, proposing the existence of quarks as the fundamental constituents of protons, neutrons, and other hadrons. Deep inelastic scattering experiments conducted at particle accelerators provided evidence for the existence of quarks and their properties, such as fractional electric charge and confinement within hadrons.

11. Leptons and Weak Interactions: The discovery and study of leptons, such as the electron, muon, and neutrinos, expanded our understanding of the particle spectrum. The weak nuclear force, responsible for processes like radioactive decay, was described by the electroweak theory, which unified the electromagnetic and weak forces.

12. The Discovery of W and Z Bosons (1983): In 1983, the W and Z bosons, carriers of the weak force, were discovered at CERN's Super Proton Synchrotron (SPS). The discovery confirmed the electroweak theory and provided experimental evidence for the unification of the electromagnetic and weak forces.

13. Neutrino Oscillations (1998): Neutrino oscillations, the phenomenon where neutrinos change from one type to another as they travel, were first observed in experiments conducted in the late 1990s. This discovery indicated that neutrinos have mass and provided insights into the properties of neutrinos and the nature of particle masses.

14. Beyond the Standard Model: While the Standard Model has been highly successful in describing particle physics, it has limitations and unanswered questions. Scientists continue to search for physics beyond the Standard Model, such as theories that unify all fundamental forces, explain the nature of dark matter and dark energy, and incorporate gravity into the framework.

15. Experimental Discoveries at the Large Hadron Collider (LHC): The LHC, the world's most powerful particle accelerator, began operations in 2008. In 2012, the LHC experiments announced the discovery of the Higgs boson, a particle associated with the Higgs field that gives mass to other particles. The discovery confirmed a key aspect of the Standard Model.

16. Neutrino Mass Hierarchy: Ongoing experiments, such as the Daya Bay, T2K, and NOvA experiments, are focused on determining the neutrino mass hierarchy, which refers to the ordering of the neutrino masses. This has implications for understanding the nature of neutrinos and their role in the universe.

17. Future Directions: The field of particle physics is continuously evolving. Future experiments, such as upgrades to the LHC (High-Luminosity LHC) and

new facilities like the International Linear Collider (ILC) and the proposed Future Circular Collider (FCC), aim to explore higher energies, search for new particles, and address unanswered questions in fundamental physics.

The history of particle physics is characterized by a series of remarkable discoveries and advancements that have deepened our understanding of the fundamental structure of matter and the forces that govern it. The field continues to push the boundaries of knowledge, with ongoing research aimed at unraveling the mysteries of the universe.

Here are some additional details about the history of particle physics:

18. Cosmic Ray Experiments: In the early 20th century, researchers such as Victor Hess and Bruno Rossi conducted experiments with cosmic rays, high-energy particles from outer space. These experiments provided important insights into the properties and interactions of particles at high energies.

19. Quantum Electrodynamics (QED): Quantum electrodynamics, developed in the 1940s and 1950s by Richard Feynman, Julian Schwinger, and Sin-Itiro Tomonaga, is a quantum field theory that describes the interactions between charged particles and electromagnetic fields. QED successfully explains phenomena such as the interaction of electrons and photons, and it is one of the most accurate and well-tested theories in physics.

20. Particle Accelerators and Colliders: Particle accelerators have played a crucial role in advancing particle physics. Accelerators allow scientists to study particles at higher energies and create new particles through collisions. Notable accelerators include the Tevatron at Fermilab, the Large Electron-Positron Collider (LEP) at CERN, and the aforementioned Large Hadron Collider (LHC).

21. Discovery of the Top Quark (1995): The top quark, the heaviest known elementary particle, was discovered in 1995 at the Tevatron accelerator. Its discovery completed the third generation of quarks in the Standard Model and provided insights into the origin of mass.

22. Search for Dark Matter: Particle physics is closely connected to the study of dark matter, a form of matter that does not interact with light and has only been observed through its gravitational effects. Experiments such as the Large Underground Xenon (LUX) and the XENON1T collaborations aim to detect dark matter particles and understand their properties.

23. Neutrino Experiments: Neutrinos continue to be a subject of intense study. Neutrino experiments such as the Sudbury Neutrino Observatory (SNO), Super-Kamiokande, and IceCube have made significant contributions to our

understanding of neutrino properties, including their oscillation behavior and masses.

24. Future Challenges: Particle physics faces several challenges and open questions. These include the search for physics beyond the Standard Model, the nature of dark matter and dark energy, the matter-antimatter asymmetry in the universe, and the possible unification of all fundamental forces.

25. International Collaboration: Particle physics is an international endeavor, with scientists and researchers from around the world collaborating on experiments and sharing data. Organizations such as CERN in Europe, Fermilab in the United States, and many others foster collaboration and enable large-scale experiments.

The history of particle physics is marked by a continuous quest to understand the fundamental constituents of matter, the forces that govern them, and the nature of the universe. It has witnessed remarkable discoveries, technological advancements, and theoretical breakthroughs, pushing the boundaries of our knowledge and inspiring new avenues of research.

REFERENCES

1. Kh. Olimov, S.L. Lutpullaev, K. Olimov, K.G. Gulamov. Physical Review C, Vol 75 067901 (2007).

2. Kh. K. Olimov. Physical Review C, Vol 76 055202 (2007).

3. Kh. K. Olimov. Physics of Atomic Nuclei, 2008 Vol 71 Pages 93-97

4. Kh. K. Olimov Physics of Atomic Nuclei, 2010 Vol 73 Pages 433-442

5. Kh. K. Olimov, M.Q Haseeb. The European Physical Journal A, 2011 Vol-47 Pages 1-16

6. Kh. K. Olimov, Mahnaz Q. Haseeb, Imran Khan. Physics of Atomic Nuclei, Vol. 75, No. 4, pp. 479-487 (2012); Kh. K. Olimov, Mahnaz Q. Haseeb, Imran Khan, A. K. Olimov, and V. V. Glagolev. Physical Review C 85, 014907 (2012).