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МИНИСТЕРСТВО ВЫСШЕГО И СРЕДНЕГО СПЕЦИАЛЬНОГО ОБРАЗОВАНИЯ РЕСПУБЛИКИ УЗБЕКИСТАН

ТАШКЕНТСКИЙ ГОСУДАРСТВЕННЫЙ ПЕДАГОГИЧЕСКИЙ УНИВЕРСИТЕТ ИМЕНИ НИЗАМИ

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Introduction

Actuality of the study. “Our common goal is to restore the former glory of science, literature and art, and to carefully preserve and develop the ancient and modern cultural traditions. These best of our nation as integrity, humility, love of neighbor, to the younger, respect for elders, care for women and children, hospitality, loyalty to one's land and people, must again find the rule in our daily life, passed to our children and grandchildren” [1]. At the beginning of XXI century, well-being and future prosperity of the country depends on the scientific and technological progress, and intellectual potential. In this regard, the first day of independence, the Republic of Uzbekistan, the President and the country's leaders have raised the question of education at the primary level. To this end, speaking at the ninth session of the Parliament of the Republic (1997), President Islam Karimov said: "Among the crucial important issues of our lives, which are reviewed and discussed at today's session of the Oliy Majlis, have bills to radically transform education and the educational system that makes it possible to raise it to

[1] The Law of the Republic of Uzbekistan "On education". August 29, 1997

the level of the requirements of modern times, to bring a bright future of harmoniously developed generation ".[2]

Noting the importance of the issue of education of the younger generation in response to the questions of the editor of "Tafakkur", Karimov said: "I have pondered over the statement of Abdullah Avloni:" Education for us - a matter of life or death, salvation or death, happiness or misfortune . "How in the early centuries of our nation were important and relevant these words of a great educator, as well, and perhaps even more important, and they are relevant to us today". [3]

One of the main principles of the national program for training is "Education and training young people on the basis of the ideology of the national revival and of the knowledge of human values, in the spirit of love of country, devotion to the ideals of independence".[4]

The preparation of highly qualified national personnel, and demanded reform of higher education. The importance of this reform was highlighted in 1993 by the President at a meeting of the Cabinet of Ministers. Then he says, in part:"... No one can remain indifferent to the fate of especially the younger generation. Considerable role here belongs to high school. Caring about methods of training and education of young people about their educational and professional level for each of us is a sacred duty. Bringing system of higher and secondary special education to international standards,scientific assessment of the need for specialists to sectors of the economy,the effective use of best practices in the training and education of young people-these issues are today the most important ". [5]

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[2] Law of the Republic of Uzbekistan "On national training programs." August 29, 1997

[3] Karimov I.A. Идеология – это объединяющий флаг нации, общества, государства (Answers to questions of the chief editor of " Tafakkur .") To Tashkent : Uzbekistan , 1999

[4] . Karimov I.A. Гармонично развитое поколение – основа прогресса страны.- Tashkent : Sharq , 1998 . p. 4.

[5] Karimov I.A. Идеология – это объединяющий флаг нации, общества, государства (Answers to questions of the chief editor of " Tafakkur .") To Tashkent : Uzbekistan , 1999 .

These discussions culminated in the adoption of the Law of Uzbekistan "On Education,"[6] and the "National Program for training" [7], the essence of which aimed to reform the educational system of the country.

One of the goals of education reform is the development and implementation of state educational standards that define requirements for the content and quality of general secondary, vocational and higher education, and then based on them - creating educational curriculum courses in continuing education.

Another important principle of state policy in the field of education specified in the Law "On Education" and the "National Program" Training is a humanistic, democratic and secular nature of education and training, as well as the humanization and democratization of the learning process (see the Law "On Education "Article 3). It should also be noted that the continuity of education are important attributes of the educational process, and they radically affect the optimality and high efficiency of the learning process. Proceedings of the National Program for Training pay special attention to these basic principles of didactics: "As you know, the basic levels of the national education system of continuous education. Therefore, it is necessary to pay special attention. By providing continuing education state educational standards and relevant training programs should pay focuses on the fact that they corresponded to the level of world standards, have been established on the basis of spirituality "[1, p.15].

When you select a problem for scientific research, we have been taken as a basis these fundamental principles of the Law "On Education" and the National Program for Personnel Training.

Based on the analysis of the content of physics and astronomy in continuing education, we concluded that the main cause of reform are notable drawbacks

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[6] Karimov I.A. О разработке Национальной программы по подготовке кадров// Учитель Узбекистана. - 1997 . March 19.

[7] Law of the Republic of Uzbekistan "On national training programs." August 29, 1997

allowed in teaching physics and astronomy in professional colleges and academic lyceums (AL). These drawbacks are mainly related to the content of the subject. Content of the subject lags behind the issues facing the company, there was a marked reduction of the impact on the formation of the individual student.

In other words, these disadvantages are:

- noticeable weakening of the content in an ideological and humanitarian aspects;
- the purpose of training is not enough focused on such vital issues as the aesthetic and environmental education of students;
- motives of study, in most cases, insufficient disclosure (often the students do not know why we study the subject);
- structure and course content often does not allow to open students' ability to suppress their interest in the subject, do not give the opportunity to implement a differentiated approach to teaching;
- been weakened role of scientists of the medieval East, our compatriots in world astronomy;
- not reflected as the materials of the forms and types of matter;
- hardly reflects the latest advances in particle physics and not enough given the current understanding of the material world.

Above reaffirm the relevance of the theme of this
final qualifying work.

In connection with problems arising by the Law "On Education" and the "National Program for Personnel Training" as well as due to changes in the structure of secondary, secondary vocational and higher education as a pedagogical research, we have chosen scientific field to study and use the materials reviewed by modern concepts of forms and types of matter.

This theme is used as additional training material for the study of (micro) "Physics of Elementary Particles" by passing the theme "The modern picture of the world" or "Modern forms of matter" on the narrow circle or optional classes for a deeper understanding of these topics, understanding the structure of the universe, the development of world .

The object of study is an educational process of teaching of elementary particle physics at secondary schools, academic lyceums, professional colleges and high schools.

The subject of study is to explore the state branch of the physics of elementary particles in continuing education.

Purpose of this study is to determine the state of training of elementary particle physics in continuous education.

Objectives of the study is to develop methods of teaching elementary particle physics in a system of continuing education.

Theoretical basis of the study : Law of the Republic of Uzbekistan "On education" and "National Program for Training"; article, the President of Uzbekistan Islam Karimov.

The level of learnt problem. Learning the problems of elementary particle physics is one of the major areas of research in modern physics, and perhaps it is a key of theoretical and philosophical problem of cognition.

The practical significance of the study materials and the results of the thesis can be used in the teaching section of elementary particle physics in continuing education.

The scientific significance of the study materials and the results of the thesis can be used in the teaching section of elementary particle physics in continuing education.

Scientific novelty:

1. The state education section of elementary particle physics in continuing education, stages in schools, secondary vocational education and higher education.

2. Studied the implementation of the principle of continuity in the training section of elementary particle physics in continuing education.

3. Proposed new topics that reflect the latest advances in particle physics, for inclusion in the educational process.

Structure of master's thesis: Master's thesis consists of an introduction, three chapters, conclusion, references and glossary.

Experimental area of research will Tashkent State Pedagogical University named after Nizami.

Chapter I. Key factors that make the principle of continuity in continuing education

1. The principle of continuity in education

The principle of continuity, consistency and systematic training due to objectively existing stages of cognition, sensory relationship and logical, rational and irrational, the conscious and the unconscious.

Continuity for the content of training, its forms and methods, strategies, and tactics of interaction of subjects in the educational process, personality tumors students. It allows you to combine and hierarchic individual learning situations in a single integrated training process of the gradual development of natural connections and relationships between objects and phenomena of the world.

The well-known Methodist A.V.Usova studying the relationship of general and special didactics, said: "in the list of the problems addressed by private didactics must enter and scientific concepts, above all the methods of forming the fundamental concepts studied academic disciplines. Among these problems, a special place is occupied by the study methodological issues and methodology of formation of concepts important attitudinal obstacles that are common to a certain cycle of academic disciplines. "[8]

L.Ya.Zorina comparing the systematic teaching of knowledge with communication of scientific knowledge with the general methods, peeps:

"To the students' knowledge acquired in various academic disciplines, were adequate system of scientific theory, ie systematized in the content of education in basic sciences than subject knowledge, it is necessary to introduce special and methodological knowledge. "[9]

Qualification training of future teachers of physics should provide a thorough scientific basis for the development of a student course in physics of secondary education, understanding the continuity between the science of physics that gives its honey buzzard at different stages of training.

The modern theory and practice of teaching explores the development of cognitive activity of students, which is primarily provided by the implementation of didactics, in particular the principle of continuity in teaching.

The essence of the principle of continuity - the preservation of individual elements or characteristics of the system during the transition to a new state. Continuity in scientific knowledge related to compliance with the principles in didactics as it can be considered as requirements for developing the content of figures subject teachers in different types of schools.

In the substantial aspect of it is manifested as a primary principle of destruction overload jobs in a phased teaching physics, conservation and development of nuclear physics knowledge during the transition from one type of school to another, maintaining a uniform level of education based introduction to the practical nature of the program material, professionally oriented, and invariant variability.

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[8] A.V.Usova Psychology in questions and answers / Tutorial . -M . : Prospect , 2005 . - 173 p.

[9] L.Ya.Zorina Pedagogy : pedagogical theories, systems , technology / ed. Smirnov . -M . : Publishing Center "Academy" , 1999. -544 P.

Using the principle of continuity at the same time requires consideration of the development of students' knowledge, skills, and methods of invariant principles - integration and interdisciplinary communication.

Said above shows the importance of the principle of continuity in the teaching of physics. Therefore, in order to improve the disclosure of teaching basic principle of continuity in the teaching of physics, we define the essence of the problem of continuity in science, physics and its teaching.

E.A.Baller continuity considering as a philosophical category is defined as follows: "......... continuity is a reality and the relationship between the different stages and the stages of development of knowledge, the essence of which is to preserve these or other elements of a whole, or the preservation of its individual components as a result of the qualitative aspects of the system changes. Continuity determines the stability of holistic in that it links the present with the past and the future. "[10]

Thus, in the modern philosophy of developing continuity refers unambiguously continuity means maintaining some of the old elements in the development of a material object.

For example, the continuity in the teaching section of particle physics consists in the fact that it is appropriate explains the basic concepts of this section guided the development of this field, the discovery of new particles, the emergence of new problems and their solutions. Such continuity can be seen in other areas of physics. It is appropriate to maintain a sequence of teaching particle physics, repeat and remember: the phenomenon of radioactivity and the discovery of the electron, Thomson's model of the atom, the experiments of Rutherford, Bohr's postulates, the structure of the nuclei of the independence of the nuclear electric charge, only then report the "atomic era" and "nuclear era "in physics, to study early observations of" strange particles "," charming particles, "etc. Such a sequence is

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[10] E.A.Baller Methods of teaching physics - M. , 1988. - 554 .

in some ways reflects a causal relationship in particle physics and tames the study of this topic. These conclusions are subject to the following opinion:

"Thus, the correspondence principle should be regarded as the principle of the development of new knowledge based on the definition of the boundaries between old and new ideas and practice the content of the correspondence principle, is the need to use the terminology used in the macro world."

Based on the analysis of the philosophical literature can identify the main provisions of the problem of continuity in training.

1. The concept of continuity reflects objectively existing in the development of nature, society and thought, characterizes communication in both the development and the development of these relations. Didactics, as a theory of education and learning, should characterize the development of these processes.

Consequently, they are inherent and continuity. This means that the concept of continuity should be didactic.

2. Continuity, as a philosophical category, is also associated with other philosophical categories. Of particular interest is a didactic analysis of the relationship of concepts such as "continuity" and

"Generalization", "continuity" and "interdisciplinary communication", "continuity" and "systematization."

1. The presence of both quantitative and qualitative phases of the development can consider the types of continuity in the knowledge-based relationship between the concepts of continuity and a generalization according to the levels of development of knowledge. Hence, this approach can be extended to the didactic study.

2. Continuity, as a philosophical category, performs tasks regulation when used in pedagogical and didactic studies, in such studies can and should be continuity serves as a methodological principle.

B.G Ananiev, analyzing the continuity of teaching, writes:

"Also yet to be resolved is one of the main educational problems, the problem of knowledge of the teachers in their teaching the basics of science. Continuity in teaching is not only one of the important conditions of this development, it has at the same time and includes a continuity in the study, ie use of the internal relationship of the studied knowledge in the minds of students, and different conditions in the teaching and life. "[11]

At each time interval training teacher decides to specific tasks. Communication and continuity of these problems create the conditions for the transition of students from simple to more complex forms of cognition, behavior and activities, ensuring their consistent solution.

Continuity in the location of the subject material and the choice of methods and means of activity on the mastery of this content is subject to content and logic of the relevant science and laws of the process of learning. It should cover not only the individual disciplines, but also the relationship between them, ie interdisciplinary communication.

One of the conditions of continuity in training is to bridge the gap between different levels of education. But the position that this requires appropriate teaching methods enabling children to age, causing some objection, since it is proved that the younger students demonstrate a higher level of capability (VV Davydov, L. Zankov, LP Peterson , El'konin) than was assumed in the traditional pedagogy. They exhibit the ability of theoretical thinking, problem willingness to think, analyze and synthesize, a willingness to reflection, the ability to make internal plan of action.

Problems of continuity of the content of the educational process of the school were considered in Dorofeev, Charles I. Ganelina, MN Lebedeva, etc., between the pre-school and primary school - in the works of L. Wenger, B. . Davydova, VT Kudryavtseva, between the elementary school and the principal, between the middle school and high school - in the works of G. Alexandrov, O. Kuznetsov, Yu Koustova, SM Yearbook, etc.; succession and continuity of vocational education - studies A. Novikova.

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[11] B.G Ananiev Educational problems M. , 1992. - 554

A number of authors see the success of continuing education in the sequence of learning and building the capabilities of the trainees, in compliance with the principle of continuity. Special emphasis is placed on the content of education, separate his subject.

An interesting approach to the study of psycho-pedagogical nature of continuity between the school and the university offered S.M. Yearbook. We fully share his thoughts on the bilateral nature of continuity, which is proved by the example of relations secondary and higher education, which is important for consistency, between kindergarten and primary school, primary and primary, middle and high school education.

System approach to continuity in the process of continuous education, in the unity and interrelation of three blocks, enhances the success of training, child health and reduce fatigue of students. A systematic approach to working with parents and teachers to enhance their educational and psychological culture of educators, psychologists, physiologists, physicians can allow or prevent the occurrence of problems in the relationship between children and teachers, psychologists, doctors, parents and children and between the children themselves, reduces conflict relationship.

Physiological factors of pupils and students play an important role in the continuity of learning in continuing education. Therefore, in this chapter we consider the physiological factors of pupils and students.

Successful teaching and formation of a harmonious personality involves:

- Good knowledge of basic physics teacher, general psychological characteristics of students, the patterns of the learning process and learning;
- Knowledge of the leading role in the formation and development of the psychological characteristics of the social experience of living and work, training, education and self;
- An understanding that precedes the development of philosophy, learning leads the development, stimulate development, reflected in its level;

-Understanding of the necessity of adopting and developing various forms of thinking a certain duration and chronology.

Characteristics and criteria of mental retardation:

- The rate of assimilation of the material;
- Profitability of thinking;
- The level of the analytic-synthetic activity (level of techniques of mental activity formed on one object to another object);

Ability to independently organize and summarize the psychological characteristics of learning theoretical physics.

Briefly about the structure of physical knowledge. It consists of two levels: the theoretical and empirically.

Empirically level. It includes the data of experience, empirically concepts: the laws and regularities. In the study of physical phenomena at the level of empirically generated experimental technique, methods, data, formulate laws and regularities. To quantify the physical phenomena introduce numerical characteristics of the measure of their properties, which are called physical quantities.

A physical quantity - is a numerical characteristic properties of physical objects, obtained by measurement.

Physical objects - the body system, the various states of these systems or processes that occur therein. Each physical quantity that describes a physical object, not only quantitatively but also qualitatively. Physical quantity - it's not reality itself - is the accepted way of describing the physics of physical reality. Every physical object has a number of properties of the original. They can use the method of idealization, that is, the allocation of significant parties and discarding irrelevant, in which the problem is reduced to the study of a simplified model (for example, a material point, the mathematical pendulum is solid).

Theoretical level. The second - the theoretical level of knowledge of the physical structure. Includes the theories, ideas and hypotheses. The physical theory - these are theoretical laws that are present in the form of mathematical expressions that describe these phenomena. They are more common include both theoretical and empirically concepts. The theory has structural parts: the base, the core, a consequence.

The base includes a physical theory empirically basis (set of experimental data), the idealized object and the physical quantities. Idealized object is - a model of matter at a certain structural level. (Each theory is different from one another idealized object. Example in electrodynamics idealized object - electron gas in quantum electrodynamics - harmonic oscillator). Transitional bridge from empirically basis for a new theory, the idealized object.

The core of the system is the physical theory of general laws expressed in mathematical equations, postulates and principles. The systems of equations represent the mathematical model of this kind of interaction of matter in which the idealized object is represented in the dynamics and movement. (In the basic equations contain the fundamental constants).

A specific and important type of physical conservation laws are the laws of conservation. Each physical theory corresponds to a certain symmetry. symmetry manifests itself in the invariance of physical laws under certain transformations (operations).

For example, moving or turning the system as a whole in a continuous transformation, replacement of particles by antiparticles a discrete transformation.

The important role played by the investigation of physical theories. They reveal the philosophical aspects of science and their development contributes to the development of scientific thinking and outlook. For example, the correspondence principle, which means that the new theory is asymptotically become the old, if the fundamental constants becomes critical. The findings are being built by logical deduction. The set of basic ideas, principles, hypotheses creates a physical picture of the world.

2. Continuity of physics teaching

Methods of teaching physics as a science - is part of the teaching of science.

Theoretical physics - the science of the most general properties and forms of matter in motion, their mathematical model of interpretation, logical explanations and evidence of extensive properties of nature.

Deeper study helps to know the world around us. It reveals the patterns of physical phenomena and helps to find ways to use these phenomena in human life. The teacher must not only know the physics, but also possess evidence - based techniques and methods of knowledge transfer to students. Only in this case, it can succeed in shaping the scientific worldview.

Requirements for teacher: knowledge and knowledge of the subject, the ability to present the material to the age of psychology and vocational guidance, deep faith in his subject artistic presentation.

Methods of teaching physics - it's education science, exploring the ways and means of teaching, its laws, ways and means of education and development of students.

Subject teaching methods of physics - is the theory and practice of teaching specific areas of physics, in particular, the theoretical physics of specific groups of students, as well as the problems of the organization and improvement of the educational process, to improve the content of theoretical physics.

The object of teaching methods of physics - didactics, psychology, physics, theoretical physics students and the teacher.

The main functions and tasks of the course:

1. Distribution and assimilation of knowledge

2.Devolopment cognitive capabilities, and the ability of self-study of the new literature, a sense of direction in the flow of scientific - technical information, logical thinking and the ability to transition from a dialectical logic, creative thinking);

3. Bringing up. (Formation of the scientific world.)

Two (2 and 3) of these functions are directly related to intellectual education, and the third indirectly.

Why teach physics and theoretical physics. What are the communication and learning process of formation of outlook.

What to teach? (Determining) the need to systematically improve the content and structure physics course.

How to teach? development, experimental testing and introduction of the most effective teaching methods and techniques of training, education and development of students, as well as the modernization of educational equipment for physics

Here we consider:

1. General questions (objective study of the physics, the structure and content of the course in physics, methods polytechnic education, communications training and practice of physics, the forms of organization of educational process and self-taught).

2. Special issues (methods of individual sections and topics in theoretical physics, methods of practical work, provision of teaching clarity).

Methods: For use in meaningful formal methods study

Teacher observation of the object - the pupils, their effect in the study of new material in the performance of laboratory work, in solving problems:

- The teacher in presenting the course in physics
- The formation of students' skills

Documentary observation (journals, written work) Every scientific observation should have a clearly defined goal and a prearranged plan.

Educational experiment - is peculiarly designed and implemented a learning process of physics, which is holding the pedagogical supervision in controlled conditions and in accordance with identifiable goals.

Teacher observation occurs in vivo, and in pedagogical experiment is an active impact on the learning process by creating special conditions for testing purposes of the experiment. The duration of the pedagogical experiment from a few weeks to several years. One of the forms of pedagogical experiment is to compare learning in experimental and control groups. In the experimental group were administered the experimental factor, which is absent in control groups.

Taken into account:

- Quantitative factor;

- The credibility of the haul;

Test performance (specially selected tasks to test students' knowledge that has a definite answer brief) survey, a theoretical analysis (structural - logical analysis of educational material and knowledge of the student, the statistical evaluation of individual training elements of physics). Systematic approach (the process of learning physics present as a complex multi-level system, which operates under the influence of various factors. construct a general model that reflects all the factors of the educational process and communication).

Physics course is a mandatory course in average pay truncation

Why? Physics develops thinking, is the science of the world around us, physics part of the overall culture of human rights;

It is the theoretical foundation of modern technology, helps to learn about the world, is an element of human culture.

Physics uses mathematics as a tool. Due to the physics of developing (now) mathematics. Physics used in geology, biology, and chemistry. The differentiation and integration of the sciences.

The objectives of teaching physics: teaching, education, development, formation and development of scientific knowledge and skills that are necessary and sufficient for understanding the phenomena and processes taking place in technology, nature and everyday life, a basic knowledge of physical theories, the ability to use that knowledge to solve standard and non-standard problems , mastery of the language of physics and the ability to use it, formation of ability to systematize the results of observations to make generalizations and assess their likelihood and limits of use; plan and conduct an experiment to use measuring, computing devices as well as information technology, the formation of the scientific world

Educational objectives of teaching physics: the formation of the scientific worldview of dialectical thinking, education of ecological thinking and behavior, hard work and perseverance, the development of logical thinking, the ability to use the methods of induction and deduction, analysis and synthesis, formulation of conclusions and generalizations, developing the ability to experiment, to think technically and develop creative ability.

The structure and content of the course in physics. There must be systematic and consistent presentation of all branches of physics and themes. As an example, in the application are: the development of a full course in high school;

Development of lecture notes on quantum physics (energy and momentum of light quanta, the Schrödinger equation, the wave function).

Requirements for building physics course should be: advanced (meet the current level of physics); affordable, stable.

In the selection of material for classes should be based on: scientific content, systematic presentation, the unity of theory and practice, the relationship physics course with other items, the distribution of data.

The main document that defines the scope and content of the course in physics, the program object, and the requirements of state educational standards.

Formation of a scientific outlook of the pupils is largely determined by:

- Specific natural - scientific discipline, in particular, physics, or more precisely - of theoretical physics.
- Level with the formation of methodological knowledge in the learning process
- The nature of the psychological characteristics of the formation of scientific thinking.
- A variety of forms and methods of teaching, as well as interpretations of theoretical physics.

Formation of methodological knowledge of students in the study of theoretical physics is the focus of modern pedagogy. It is also important from the viewpoint of improving the quality of education, and from the point of view of the formation of scientific thinking of students.

It is assumed that the methodological knowledge can solve a number of problems of contemporary physical education, such as consistency, convergence of scientific and academic knowledge, to increase the level of cognitive motivation, improving the quality of knowledge of physics, and even reduce the informational content of learners.

Also interesting is the idea of the feasibility of the formation of methodological knowledge in unity with the application and the social and natural problems. This methodical idea has deep philosophical roots, as based on the philosophical idea of the intimate connection of materiality and intelligibility of the world.

It is necessary to find out what kind of psycho-educational prerequisites exist for the formation of methodological knowledge of students in the classroom for Theoretical Physics, and what the results of intellectual and creative abilities can be expected as a result of this formation.

Formation of a scientific world view, scientific thinking and organization of scientific knowledge depends on: the level of development of abstract and logical thinking person;

- Continuous improvement of teaching methods of theoretical physics;

-A thorough scientific analysis of its current achievements;

-Correct scientific definition of strategies and prospects of development of modern theoretical physics.

In the direction of teaching methods is productive, informative approach to the development of the student. The most effective methods include training seminar events on problems of theoretical physics. This stage has a special role in the development of psychology and the formation of intelligence of the person.

A study of state education section of particle physics in secondary schools, academic lyceums and professional colleges, the problems of teaching methods in this section, as well as on the basis of the results of the final qualifying work can make the following conclusion:

• studied physiological factors of students being one of the factors of the implementation of the principle of continuity.

• studied physics interdisciplinary communication with other items to ensure implementation of the principle of continuity in the section studying the physics of elementary particles in the system of continuous education.

Conclusions on the first chapter.

The first chapter describes the basic principles of continuity in continuing education, taking into account psycho-physiological factors accounting students and interdisciplinary communication in the teaching of physics.

Teachers need to know the psychology students, pupils and students. Psychology student or student shows their positive and negative sides. In addition, teachers should use the principle of continuity in continuing education. The principle of continuity is good and helps to develop the theme luchsche. Because continuity allows students to learn new information consistently. And it facilitates the development of themes. Pupils or students learning new subjects and in the process of studying the concepts encountered unknown to them. Definition of these concepts was given through a lesson or two lessons. With the principle of continuity of such convenience; they excluded. Knowledge of psychology students and facilitates the use of the principle of continuity management lesson.

Chapter II. Continuation of the study subjects "Elementary particles" in continuing education

1. Examining the status of teaching about the "Elementary particles" in a secondary school.

Today physics as a subject taught in secondary school 272 hours. Hours allotted to study the physics of work performed by most programs for the teachers. There are objective and subjective factors. Some teachers believe that the study of physics important based on experimental knowledge than theoretical. This stereotype is now considered excellent.

The principle of continuity, consistency and systematic training due to objectively existing stages of cognition, sensory relationship and logical, rational and irrational conscious and unconscious.

Continuity for the content of teaching, its forms and methods, strategies and tactics of interaction of subjects in the educational process, personal neoplasm's trainees. It allows you to combine and hierarchic individual learning situations in a single integrated training process of the gradual development of logical connections and relationships between the types of continuous learning physics.

In each time slot teacher training to solve specific problems. Communication and continuity of these problems create the conditions for the transition of students from simple to more complex forms of cognition, behaviour and activities , providing consistent their decision. Consistent and systematic learning allow resolve the contradiction between the need to develop a system of knowledge and skills in the subjects and the formation of a holistic conceptual vision of the world Above all, it provides system building programs and textbooks and the establishment of intersubject and intrasubject communications .

Development of a systematic approach to training allowed more clearly structured learning material, training kits, and create visual aids to learn the academic subjects. Structuring system requires the isolation of the material under study in the leading concepts and categories, establishing their relationships with other concepts and categories (causal, functional, etc.), the disclosure of their genesis.

In educational practice of the principle of continuity , consistency and systematic realized in the process of thematic planning , when the teacher outlines the sequence of individual sections of the study , those questions , selects content , outlines the system of lessons and other forms of organization of the learning process, planning assimilation , repetition, reinforcement and forms of control .

In real time physics as general educational subject is studied in 272 school classes 6-9 hours. According to the calendar and thematic plan on physics for grades 6-9 Secondary school study of particle physics is not provided in only 3 quarters assigned to Class 9 for 1 hour, only 5 hours for the consideration of those “Atom and structure of the Atom”, “Structure of the atomic nucleus. Protons and neutrons”, “Nuclear energy”, “Use of nuclear energy”, “The work conducted in the field of nuclear physics in Uzbekistan”. Study section of elementary particle physics in secondary schools is not provided. It is at this stage they will study section of elementary particle physics. But preliminary knowledge and understanding of elementary particles they are formulated with the study section "Basics of nuclear physics". Now let us study the course on the state of physics in secondary schools. Each section, each subject is studied disciples experienced teachers using different methods. After passing each subject theoretical material will be stronger problem solving. As independent work students themselves will study topics reserved home and on the subject will solve the problem. In most secondary schools physics lessons are conducted on the basis of modern information technology. The use of modern information technology makes it easier to learn the course material.

At secondary school contents of this section are as follows:

Atom and structure of the Atom

An atom consists of a positively charged nucleus and orbiting electrons negatively charged particles that make up its electron shell . Sum of the charges of the electrons is equal modulo the positive charge of the nucleus , so the atom as a whole is electrically neutral system. Size of an atom determines the size of the electron shell and of the order of 10-8 cm

Masses of various elements range from 1.6 × 10 24 - to - 4CH10 '22

In nuclear physics, mass, charge and energy are measured by special units.

Weight is measured in atomic mass units (amu) . Adopted for the atomic unit 1/12 the mass of carbon atoms equal to 1.66057 × 10 ^ -30 g

Electron has a mass of 9.11 × 10 = ME ^ 28 g @ 0.00055 amu

Called the elementary charge, which is equal to the absolute value of the electron charge : e = 1 × 10 -19 1,601 Cal = 4.802 × 10 -10 in units CGSE .

Energy is measured in electron volts (eV). EV corresponds to the energy acquired by an electron motion in an electric field with a potential difference in 1B (V) : 1 eV = 3.8276 × 10 20 cal (calories). In nuclear physics, is often used unit , a million times more :

1 MeV = 106 eV = 1.602 × 10 6 erg = 3.83 × 10 -14 cal = 1,60219 • 10-13 J.

Electrons in the shell of an atom are arranged in layers . The number of layers is the electronic serial number of the chemical element in the periodic table DI Mendeleev.

In the first , closest to the core layer to a rotating no more than two electrons. The next layer followed L - not more than 8 in the layer M - no more than 18 , and the fourth layer of N - no more than 32 electrons. Thus , the greatest number of layers of these electrons is equal to twice the square of the layer number Z = 2n2. Subsequent layers of this rule is violated , and the number of electrons can be: in the fifth layer O - from 1 to 29 , in the sixth layer of the P - 1 to 9 and an additional (top) layer of the Q - no more than 2 electrons.

Each atom exists only in certain discrete energy states corresponding to a strictly defined value of its energy.

Transition of an atom from one energy state to another is accompanied by absorption or emission of energy. In the normal state, the atom is not radiate.

If one of the electrons in a collision with a particle from outside will give some extra energy , it will move to a more remote orbit of the layer , which corresponds to its new energy . In this case, the atom is in an excited state, and then one of the electrons of the outer layer jumps to the vacated spot. After a short time (about 10-8 s), the atom returns to its normal state , thereby emitting visible light , ultraviolet or X-ray radiation . If an electron atom gets more energy, it will be absolutely knocked out (removed) from the atom. The atomic nucleus composed of positively charged particles (protons) and neutral particles devoid of charge (neutron). Both of these particles is usually called nucleons.

Proton - material particle which has a mass MR = 1.6726. 10-24 g = 1.007275 amu Positive charge is 1e +. Since the mass of the neutron (mn = 1,008665 amu) only 0.14 % greater than the mass of the proton, in the calculations, this difference is usually not taken into account and the mass of the neutron is considered almost equal to the mass of the proton.

Size of the nucleus is very small: 10-12-10-13 cm (core 100 000 times smaller than an atom) . Despite the small size of the nucleus it is concentrated 99.95 % of the mass of the atom. In view of this the density of nuclear matter is very large and of the order of 1017 kg/m3.

Nuclear charge, expressed in terms of elementary units, numerically equal to the ordinal number of the element in the periodic table of Mendeleev. This enables ordinal element Z determines the number of protons in the nucleus of the atom.

The total number of nucleons in the nucleus of an atom can be determined by the so-called mass number A. The mass number - it is rounded to whole units atomic weight of the element. Since the number of protons in the nucleus is numerically equal to the ordinal number of the element Z, the number of neutrons is equal to the difference between the mass number A and serial number Z, ie N = A - Z. For example, helium is Z = 2 and A = 4, then in the nucleus of a helium atom two protons and two neutrons.

Thus, the position of the element in the periodic table DI Mendeleev and its atomic weight reveal not only the structure of the atom, but also the structure of its nucleus.

Kind of atoms with given numbers of protons and neutrons is called a nuclide.

The atomic weight of the elements in the table is almost always expressed as fractions. This is due to the fact that almost every element in fact consists of several kinds of elements having the same electric charge but different masses, i.e. the same number of protons in the nucleus, but a different number of neutrons. Varieties of a chemical element with the atomic nucleus in the same number of protons but a different number of neutrons are called isotopes.

All isotopes of the element are accommodated in single cell elements in the periodic table. Fractional atomic weight of the element and in this case reflects the average value of the atomic weights of all isotopes of that element. Currently, more than 1,500 known isotopes, of which no more than 300 stable (kernels for a long period of time do not change), the rest are radioactive (kernels eventually break).[12]

Atomic nuclei structure.

The core is a central portion of an atom. It focused a positive electric charge and most of the mass of the atom, compared with the radius of the electron orbits the nucleus is extremely small dimensions: 10-15-10-14 m nuclei of all atoms consist

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[12] Nasriddinov K., Porsakhonov A., Mansurova M. Elementar zarralar fizikasi. Uslubiy qo'llanma.-T.: TDPU, 2007 . -31 B.

of protons and neutrons have almost the same mass, but only proton carries a electric charge.

The total number of protons is called an atom of atomic number Z ,which is the same number of electrons with neutral atoms. Nuclear particles (protons and neutrons),called nucleons are held together by a very large force,by their nature, these forces can be neither electric nor gravitational and largest are many orders of magnitude greater than the forces binding electrons to the nucleus .

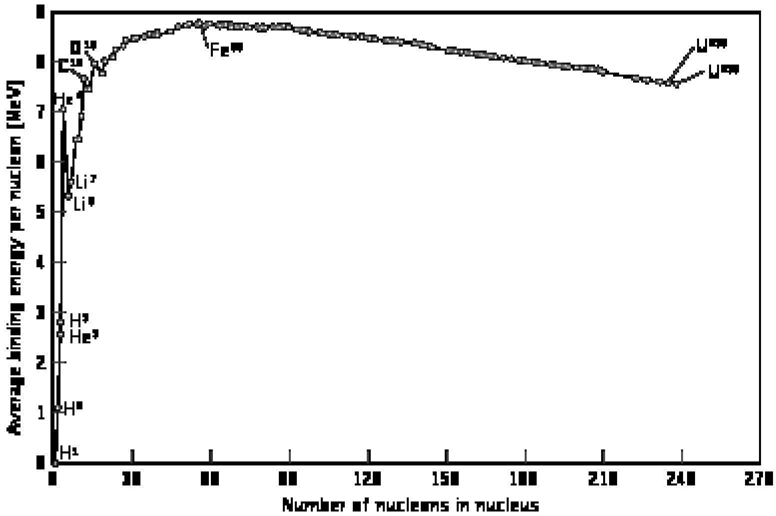
The first idea of the true size of the nucleus gave Rutherford's experiments on the scattering of alpha particles in thin metal foils . Particles deeply penetrated the electron shells and rejected , approaching charged nucleus. These experiments clearly showed a small size of the central core , and pointed to a method for determining the nuclear charge . Rutherford found that alpha particles approaching the center of positive charge at a distance of about 10-14 m, and it allowed him to conclude that this is the maximum possible radius of the nucleus .

On the basis of these assumptions, Bor built his quantum theory of the atom explain successfully discrete spectral lines , the photoelectric effect , X-rays and the periodic system of elements. However, Bohr's theory , the nucleus was a positive point charge .

Nucleus of most atoms were not only very small - they can not operate such facilities excitation optical phenomena as arc spark , flame , etc. Indication of the presence of some of the internal structure of the nucleus was the discovery in 1896 A.Bekkerelem radioactivity. It turned out that the uranium , radium, and then , polonium , radon , etc. emit not only short-wave electromagnetic radiation , X-rays and electrons (beta - rays) , but the heavier particles (alpha rays), and they can only come out of the massive part atom. Rutherford used alpha particles of radium in his experiments on the scattering , which served as the basis for the formation of representations of the nuclear atom. (At that time it was known that alpha particles - this helium atoms stripped of their electrons , but the question - why do some heavy atoms spontaneously emit them , the answer was not there, as there was no accurate idea of the size of the nucleus.)

nuclear energy

Nuclear energy (nuclear energy) - the energy contained in the nucleus and released in nuclear reactions.



binding energy

Dependence of the binding energy per nucleon , the number of nucleons in the nucleus is shown in the chart.[13]

Energy, which is not required to share the kernel on the individual nucleons, called the energy penetrating communication. I regard energy , per nucleon , different for different chemical elements and even isotopes of the same chemical element . Specific energy of a nucleon in the nucleus varies , on average, in the range of 1 MeV in light nuclei (deuterium) to 8.6 MeV , in medium weight nuclei (A ≈ 100). In heavy nuclei (A ≈ 200) the energy of the nucleon is less than the average weight of kernels , about 1 MeV , so that their transformation into the nucleus of average weight (divide into 2 parts) is accompanied by the release of energy in an amount of about 1 MeV per nucleon or about 200 MeV per nucleus . The conversion of light nuclei into heavier nuclei gives even greater energy gain per nucleon. For example, reaction of a compound of deuterium and tritium 1DI one Ti → 2He4 +0 n1

Use of nuclear energy

First Uranium as a new energy source pointed Academician Vernadsky in 1914 he wrote:

[13] Nasriddinov K. elementary zarralar fizikasi / Maruza badwords . -T . University , 2002 . -44 B .

"... A huge source of energy is a million times more than all the sources of strength, which were drawn by human imagination. Will people use this power to direct it for good, and not to self-destruct? ".

Energy fission of uranium or plutonium is used in nuclear and thermonuclear weapons (as starter thermonuclear reaction). There were experimental nuclear rocket engines, but they were tested only on Earth and in controlled conditions, because the danger of radioactive contamination in the event of an accident. At nuclear power plants, nuclear energy is used to produce heat that is used for power generation and heating. Nuclear power plants have solved the problem of ships with unlimited navigation area (nuclear-powered icebreakers, nuclear submarines , nuclear aircraft carriers). Given the shortage of energy resources, nuclear power is considered the most promising in the coming decades.

Fusion energy is used in the hydrogen bomb.

Proton and neutron

At the center of every atom lies its nucleus, a tiny collection of particles called protons and neutrons. In this article we'll explore the nature of those protons and neutrons, which are made from yet smaller particles, called quarks, gluons, and anti-quarks (the anti-particles of quarks.) *(Gluons, like photons, are their own anti-particles)*. Quarks and gluons, for all we know today, may be truly elementary (i.e. indivisible and not made from anything smaller). But we'll return to them later.

Strikingly, protons and neutrons have almost the same mass — to within a fraction of a percent:

0.93827 GeV/c^2 for a proton,

0.93957 GeV/c^2 for a neutron.

This is a clue to their nature: for they are, indeed, very similar. Yes, there's one obvious difference between them — the proton has positive electric charge, while the neutron has no electric charge (i.e., is `neutral', hence its name). Consequently the former is affected by electric forces while the latter is not. At first glance this difference seems like a very big deal! But it’s actually rather minor. In all other ways, a proton and neutron are almost twins. Not only their masses but also their internal structures are almost identical.

Because they are so similar, and because they are the particles out of which nuclei are made, protons and neutrons are often collectively called “nucleons”.

Protons were identified and characterized around 1920 (though they were discovered earlier; the nucleus of a hydrogen atom is simply a single proton) and neutrons were discovered around 1933. The fact that protons and neutrons are very similar was understood almost immediately. But the fact that protons and neutrons have a measurable size, comparable in size to a nucleus (about 100,000 times smaller in radius than a typical atom), wasn’t learned til 1954. That they are made from quarks, anti-quarks and gluons was gradually understood in a period lasting from the mid-1960s to the mid-1970s. By the late 1970s and early 1980s, our understanding of protons and neutrons and what they are made of had largely stabilized, and has remained essentially unchanged since then.

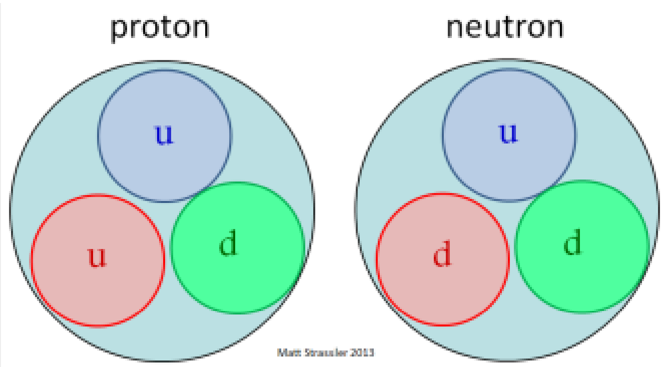
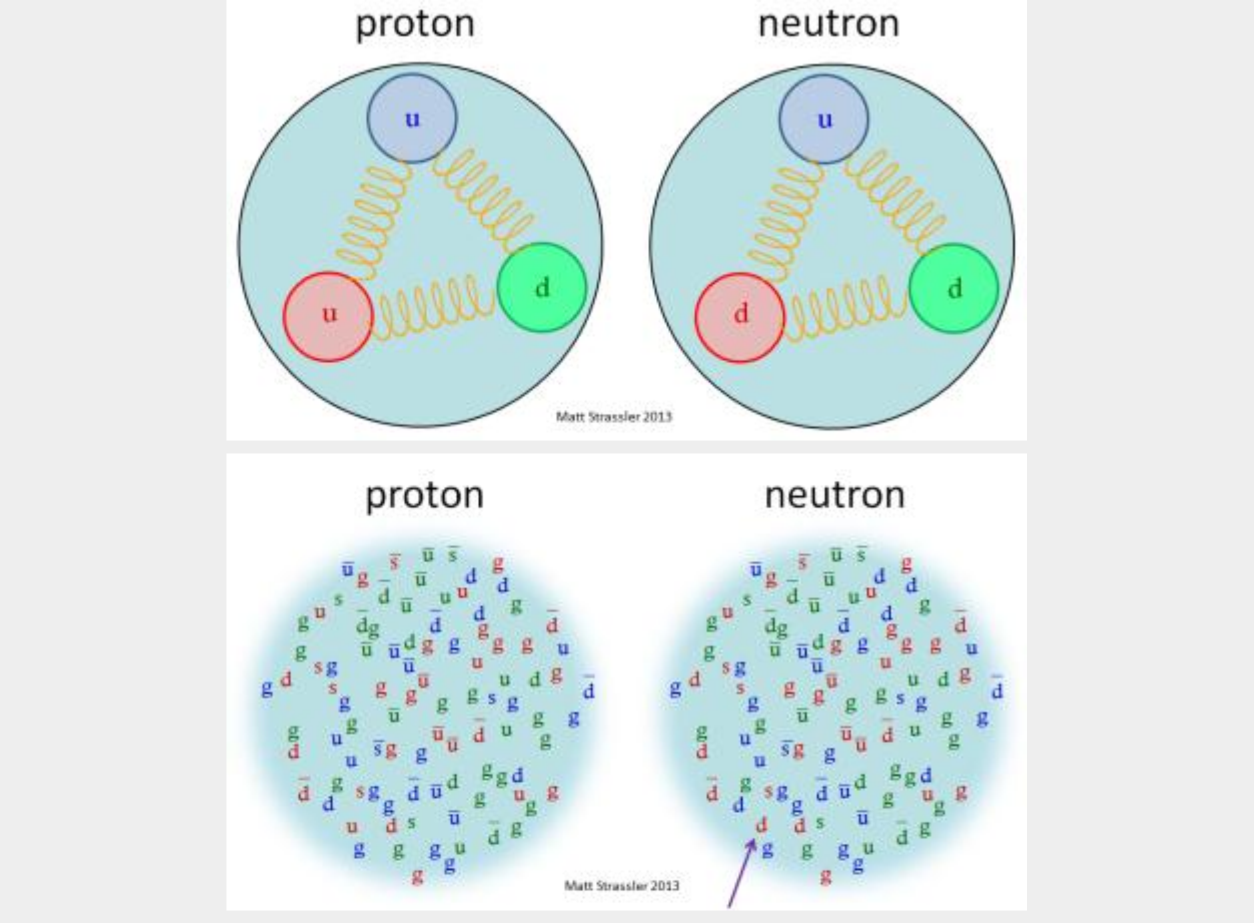


Fig. 1: An oversimplified vision of protons as made from two up quarks and a down quark, and neutrons as made from two down quarks and an up quark — and nothing else.



Nuclear energy

Nuclear energy usually means the part of the energy of an atomic nucleus, which can be released by fusion or fission or radioactive decay.

Nuclear energy may also refer to:

Nuclear Energy is a bronze sculpture by Henry Moore that is located on the campus of the University of Chicago at the site of world's first nuclear reactor, Chicago Pile-1.

The sculpture was commissioned by the B. F. Ferguson monument fund.[2]

It's a rather strange thing really but I'd already done the idea for this sculpture before Professor McNeill and his colleagues from the University of Chicago came to see me on Sunday morning to tell me about the whole proposition. They told me (which I'd only vaguely known) that Fermi, the Italian nuclear physicist, started or really made the first successful controlled nuclear fission in a temporary building. I think it was a squash court - a wooden building - which from the outside looked entirely unlike where a thing of such an important nature might take place. But this experiment was carried on in secret and it meant that by being successful Man was able to control this huge force for peaceful purposes as well as destructive ones. They came to me to tell me that they thought where such an important event in history took place ought to be marked and they wondered whether I would do a sculpture which would stand on the spot. (Henry Moore quoted in *Art Journal*, New York, spring 1973, p.286).

The sculpture is described as 14.0 feet (4.3 m) in height and 8 feet (2.4 m) in diameter by the Smithsonian Institution, and it sits atop a base that is 1.5 feet (0.46 m) in height and 10 feet (3.0 m) in diameter. However, the University of Chicago says it is only 12 feet (3.7 m) in height. The Henry Moore Foundation lists its height at 3.66m.The sculpture reminds some of the human skull, while it reminds others of an atomic mushroom cloud.

The sculpture was erected for and dedicated at the celebration of the 25th anniversary of the splitting of the atom on the grounds by Enrico Fermi on December 2, 1942. Thus, it was dedicated at precisely 3:36 p.m. on December 2, 1967.The site of the first nuclear reaction received designation as a National Historic Landmark on February 18, 1965 and was added to the newly created National Register of Historic Places (NRHP) on October 15, 1966 as one of the original designated historic places. Chicago Pile-1 is one of four Chicago NRHPs on the original list. The site was named a Chicago Landmark on October 27, 1971.

Nuclear Physics in Uzbekistan

Institute of Nuclear Physics (INP) was founded in 1956 in Tashkent. Throughout its history, INP conducted research in high energy physics, physics of atomic nuclei, activation analysis and radiochemistry, radioisotope technologies, solid state physics and radiation hardness of materials, reactor technologies, physics of accelerators etc. The main products of Institute are reactor and cyclotron isotopes, water purification devices, non-standard equipment etc.

Department of nuclear physics

The main areas of research, carrying out in Department of nuclear physics

- Particles production processes, exotic nuclear state in nuclei interactions in wide energy range
- Two-partial hadronic decay of the vector mesons, calculation of nucleon properties and their interactions in nuclear matter;
- Elastic, inelastic and quasi-elastic scattering of nucleons, light nuclei clusters in the frames of Glauber-Sitenko diffraction theory;
- KIR+(ß-decay), KIR+(K-capture) type resonance processes, determination of width of nucleon resonances;
- Excited states in deformed no axial nuclei, as well as super deformed nuclei with isomeric states properties investigation for applications;
- Quantum properties of excited states in nuclei in a wide range of mass numbers, as well as, study of kinetic energy and charge of fission fragments;
- Nuclear reactions with nucleon and nucleon associations transfer for obtaining spectroscopic information and its use in solution of nuclear astrophysics problems at very low energies;
- Development of three-particle calculation method to study light nuclei clusters decay, the asymptotic of three-particle wave functions for nuclear resonance system;
- Research for surface barrier and sub barrier resonance state of light nuclei, as well as, the nuclear-molecular system and their properties in quasi-bound states;
- Research for electromagnetic properties of conducting and plasma mediums in stationary gravitational field;
- Research for evolution of quantum multi particle systems;
- Research for properties of first wall coatings of thermonuclear reactors and other reactor materials by nuclear-physical methods.

Department of solid state radiation physics and nonmaterial physics

The main areas of researches, carrying out in the Solid State Radiation Physics Department

- Research for processes of formation, accumulation, transformation and radiation defects decay, in semiconductors, dialectical, optical, ceramic, laser, electric insulating, polymeric, construction materials and fabrications on their basis under influence of electron, proton, gamma and neutron irradiation;
- Research for radiation-stimulated processes and phase transformations, originating under influence of ionizing and nuclear irradiation, thermal treatment, laser radiation and combined radiation-thermal effect in crystal, construction, fuel and other materials of wide range;
- Determination the state, type, defects component and phase composition of formed structures and elaboration the methods of new phase formation with necessary parameters (for achieving the given properties and characteristics of materials and products;
- Research for physics and chemistry doping of semi-conductor, oxide, fluoride crystals, glass-shaped and High temperature superconductive materials. Study for the nature, parameters of forming solid solutions and structural defects, phase composition of the material, their effects both on electro physical, optical, dialectical and mechanical properties and on structural parameters of the material;
- Research of degradation parameters and properties of semiconductor, laser, optical, dielectrically, ceramic, electric insulating products spontaneously, in the field of radiation-thermal effect and exposing them by radiation sensitivity.
  Development for theoretical models of formation defects for various kinds(forms) of crystals and products under radiation effect;
- Research for crawling (sliding) and corrosion resistance processes of construction materials under temperature and radiation effect;
- The modification and stabilization properties of semiconductor, optical, laser, dialectical crystals and products by radiation technology and radiation-thermal treatment. Carrying out the transmutantive doping of silicon mono crystals by helping neutron irradiation. The synthesis and thermo-radiation treatment of High temperature superconductive materials in the field of gamma-radiation.

Department of nuclear analytics, general and applied radiochemistry

The main areas of researches, carrying out in the Department of Activation analysis and radiochemistry

- Research for conformity natural laws distribution of radioactive elements in multi component systems in the process of sorption, extraction and ion exchange;
- Radiochemical research of nuclear reaction products and development of scientific bases(foundations) for obtaining and isolating of frequentative, nuclear, cyclotron radionuclide’s;
- Development of radiochemical production technology of radiation sources and obtaining of labeled junctions;
- Development of extraction, sorption and other methods of separation and secretion radioactive elements for their subsequent analysis;
- Study for conformity natural laws of radioactive elements behavior and state (natural and artificial) in the objects of environment;
- Development of new and improving existing cleaning methods of liquid radioactive wastes;
- Development of nuclear-physical and radiochemical analytical methods of analysis for chemical elements in the environmental objects;
- Development of methodical bases for neutron-activation analysis of biomedical objects;
- Development the complex of works for instrumentation and radiochemical methods of analysis for pure and super-pure materials, noble rare metals in ores, on nuclear reactor base and in high-powered radionuclide sources of neutrons;
- Carrying out for large-scale ecological-agricultural and hydro-geochemical researches on the basis of elaborated analytical methods.[14]

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[14] Rolandi L. The LHC machine and experiments. Proc. of the XXII Int. Symp. "Lepton and Photon Interactions at High Energies". Uppsala University, Sweden, 30 june - 5 July, 2005 . - P.66- 69.

Analyzing the study of elementary particle physics section in continuing education to the following conclusions:

Extras on "proton and neutron" in secondary schools must inform students about other elementary particles, as well as displaying an animation films various processes involving elementary particles. Extensive use of computer technology ensures clarity of printed educational process and help to better master the subject.

2. Examining the status of teaching about the "Elementary particles" in academic lyceums humanities, vocational colleges, academic lyceums directions exact and natural sciences.

Studied physics in academic lyceums and secondary humanities special professional colleges 160 hours. In academic high schools for the study of humanities in "Elementary Particle Physics" set aside for 2 hours and secondary specialized vocational colleges as well. In academic lyceums direction of social sciences and vocational colleges to study the physics of elementary particles aside for 2 hours. Section of elementary particle physics is studied in a 3- course. Students studying the theme “Elementary particles”.

In the areas of humanities and vocational colleges contents of this section are as follows:

Elementary particles

In particle physics, an **elementary particle** or **fundamental particle** is a particle whose substructure is unknown, thus it is unknown whether it is composed of other particles. Known elementary particles include the fundamental fermions(quarks, leptons, ant quarks, and ant leptons), which generally are "matter particles" and "antimatter particles", as well as the fundamental bosons (gauge bosons and Higgs boson), which generally are "force particles" that mediate interactions among fermions' particle containing two or more elementary particles is a *composite particle*.

Everyday matter is composed of atoms, once presumed to be matter's elementary particles—*atom* meaning "indivisible" in Greek—although the atom's existence remained controversial until about 1910, as some leading physicists regarded molecules as mathematical illusions, and matter as ultimately composed of energy. Soon, subatomic constituents of the atom were identified, although as the 1930s opened, only the electron, photon, and proton were known. By then, the recent advent of quantum mechanics was radically altering conception of particles, as a single particle could seemingly span a field as would a wave, a paradox still defying satisfactory explanation.

Via quantum theory, protons and neutrons were found to contain quarks—up quarks and down quarks—now considered elementary particles. And within a molecule, the electron's three degrees of freedom (charge, spin, orbital) can separate via wave function into three quasi particles (Holon, spinon, orbiton).[6] Yet a free electron—which, not orbiting an atomic nucleus, lacks orbital motion—appears unpalatable and remains regarded as an elementary particle.

Around 1980, an elementary particle's status as indeed elementary—an *ultimate constituent* of substance—was mostly discarded for a more practical outlook, embodied in particle physics' Standard Model, science's most experimentally successful theory. Many elaborations upon and theories beyond the Standard Model, including the extremely popular string theory, double the number of elementary particles by hypothesizing that each known particle associates with a "shadow" partner far more massive, although all such super partners remain undiscovered. Meanwhile, an elementary boson mediating gravitation—the graviton—is generally presumed, but remains hypothetical.

All elementary particles are—depending on their *spin*—either bosons or fermions. These are differentiated via the spin–statistics theorem of quantum statistics. Particles of *half-integer* spin exhibit Fermi–Dirac statistics and are fermions. Particles of *integer* spin, in other words full-integer, exhibit Bose–Einstein statistics and are bosons.

A particle's mass is quantified in units of energy versus the electron's (electron volts). Through conversion of energy into mass, any particle can be produced through collision of other particles at high energy, although the output particle might not contain the input particles, for instance matter creation from colliding photons. Likewise, the composite fermions protons were collided at nearly light speed to produce a Higgs boson, which elementary boson is far more massive. The most massive elementary particle, the top quark, rapidly decays into, but apparently does not contain, lighter particles.

When probed at energies available in experiments, particles exhibit spherical sizes. In operating particle physics' Standard Model, elementary particles are usually represented for predictive as point particles, which, as zero-dimensional, lack spatial extension. Though extremely successful, the Standard Model is limited to the microcosm by its omission of gravitation, and has some parameters arbitrarily added but unexplained. Seeking to resolve those shortcomings, string theory posits that elementary particles are ultimately composed of one-dimensional energy strings whose absolute minimum size is the Planck length.

Analyzing the study of elementary particle physics section in continuing education to the following conclusions:

In the humanities academic lyceums and professional colleges theme "Quarks" must expand the provision of animated films already. Extensive use of computer technology ensures clarity of printed educational process and help to better master the subject.

Studied physics in academic lyceums 704 hours on 3 course. "Elementary Particle Physics " in academic lyceums direction of exact sciences studied 20 hours. In academic lyceums directions studied Natural Sciences. In the areas of exact sciences contents of this section are as follows:

"The concept of elementary particles" , "Methods for detecting particles . Accelerators "," Park Elementary Particles" ,"Antiparticles . Discovery of the positron "," Characteristics of elementary particles" , "Conservation laws in elementary particle physics . "

Studied physics in academic lyceums natural sciences 160 hours. "Elementary Particle Physics " in academic lyceums natural sciences studied 2 hours. In the areas of natural sciences contents of this section is follow: “Elementary particles”

In the areas of exact sciences contents of this section are as follows:

Concept of elementary particles

Classification of elementary particles

Elementary particle - a collective term referring to the micro-objects in subnuclear scale that can not be split (or until it is proven) into its component parts . Concept of elementary particles is based on the fact that the discrete structure of matter. Several of the elementary particles have a complex internal structure, but share them apart is not possible. Other elementary particles are structureless and can be considered primary fundamental particles .

Largest spin all elementary particles are divided into two classes:

fermions - particles with half-integer spin (eg , electron, proton, neutron,neutrino) ;

bosons - particles with integer spin (eg photon) .

By types of interactions of elementary particles are divided into the following groups :

hadrons - particles involved in all kinds of fundamental interactions leptons - fermions , which have the form of point particles (ie, consisting of nothing) up to the scale of the order of 10-18 m not participate in strong interactions. Participate in electromagnetic interactions experimentally observed only for the charged leptons (electron, mIon, tau leptons) and was not observed for neutrinos.

Quarks - fractionally charged particles that make up hadrons. In the free state was observed. As leptons divided into 6 types, and is unstructured, but unlike leptons involved in the strong interaction.

Gauge bosons - particles, which are carried out through the exchange interaction:

Hadrons and leptons are the substance.

Elementary particle - a collective term referring to the micro-objects in sub nuclear scale that can not be split into its component parts.

It should be borne in mind that some elementary particles (electrons, photons, quarks, etc) is currently considered to be unstructured and are considered as primary fundamental particles. Other elementary particles (so-called composite particles - protons, neutrons, etc.) have a complex internal structure, but, nevertheless, in the modern view, split them apart is impossible (see confinement).

Structure and behaviour of elementary particles studied the physics of elementary particles.

The magnitude of the spin

All elementary particles are divided into two classes:

• bosons - particles with integer spin (eg , photon, gluon , and mesons) .

• fermions - particles with half-integer spin (eg , electron, proton, neutron , neutrino) ;

By types of interactions

Elementary particles are divided into the following groups :

composite particles

• hadrons - particles involved in all kinds of fundamental interactions. They are made of quarks and divided , in turn, on :

• mesons - hadrons with integer spin , ie are bosons ;

• baryons - hadrons with half-integer spin , ie fermions . These include, in particular, the particles that make up the nucleus of an atom - the proton and neutron .

Fundamental (structureless) particles

• leptons - fermions , which have the form of point particles (ie, consisting of nothing) up to the scale of the order of 10-18 m not participate in strong interactions. Participate in electromagnetic interactions experimentally observed only for the charged leptons (electron, muon , tau leptons) and was not observed for neutrinos . 6 known types of leptons.

• Quarks - fractionally charged particles that make up hadrons. In a free state is not observed (to explain the absence of such observations, a mechanism of confinement) . As leptons divided into 6 types, and are considered to be unstructured, but unlike leptons involved in the strong interaction .

• gauge bosons - particles, which are carried out through the exchange interaction :

• Photons - particles carrying electromagnetic interference;

• Eight gluons - particles carrying the strong interaction ;

• Three intermediate vector bosons W +,W- and Z0, carrying the weak interaction ;

• Gravitons - hypothetical particles carrying the gravitational interaction . The existence of gravitons, though not yet proved experimentally due to the weakness of the gravitational interaction is considered quite probable , but the graviton is not included in the Standard Model of elementary particles.

Hadrons and leptons are the substance. Gauge bosons - photons that different types of interactions.

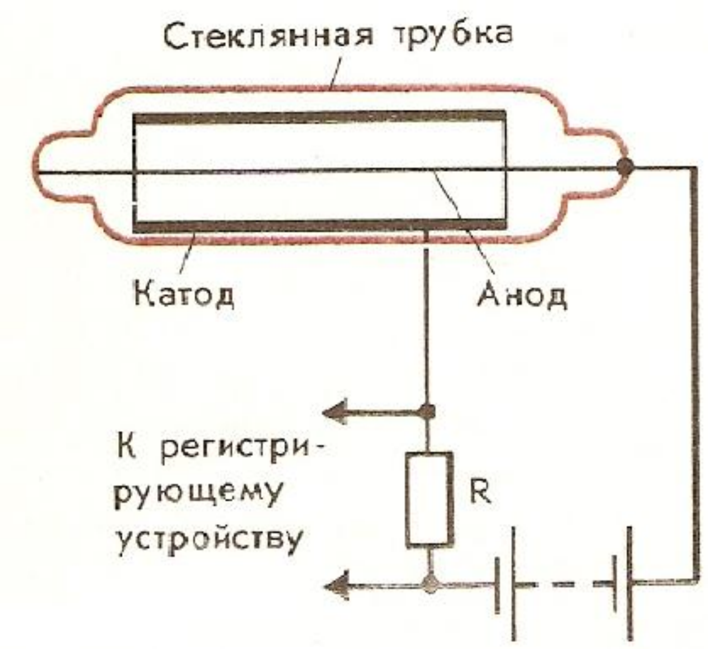
Furthermore, in the standard model with the need to present the Higgs boson , which, however, has not yet been observed experimentally .

Registration methods of elementary particles. Accelerators

1) The gas-discharge Geiger

Geiger- one of the most important instruments for automatic particle counting .

The counter consists of a glass tube coated internally with a metal layer (cathode) and a thin metal wire extending along the axis of the tube (anode) .



The tube is filled with gas , typically argon. Action is based on the counter impact ionization. Charged particles (electrons , J- particle , etc.) , flying in the gas separates from the atomic electrons and creates positive ions and free electrons . The electric field between the anode and the cathode (these voltages are) accelerates the electrons to an energy at which the impact ionization begins . There is an avalanche of ions and the current through the meter increases dramatically. At the same time across the load resistor R is formed voltage pulse , which is fed to a recording device . To counter could record the following hit him particle avalanche discharge must be repaid . This occurs automatically. Since the moment of occurrence of the current pulse the voltage drop on the discharge resistor R is large, the voltage between the anode and the cathode decreases sharply-so that the discharge is terminated.

Geiger counter is used primarily to detect electrons and Y- rays (high energy photons). However directly Y- rays due to their low ionizing power are not registered. For detection of the inner wall of the tube coated with the material from which the Y- rays knock electrons .

Counter registers almost all the incident electrons him , but that the Y- rays , it enrolls approximately only one Y- quantum of a hundred. Register heavy particles (eg , J- particles) is difficult because it is difficult to do in the counter thin enough "window" transparent to these particles.

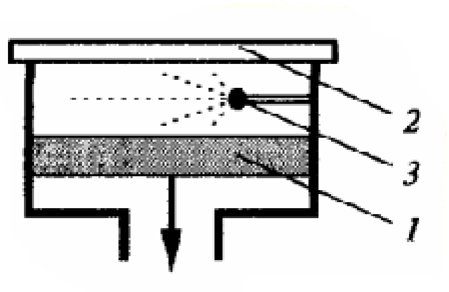


Рис. 2

2) The cloud chamber Action cloud chamber based on the condensation of supersaturated vapor ions to form water droplets . These ions creates along its trajectory moving charged particle .The device consists of a cylinder with a piston 1 (Fig. 2) covered with a flat glass lid 2 . In the cylinder are saturated water vapor or alcohol . Analyzed is introduced into the chamber 3 a radioactive drug , which forms ions in the working volume of the chamber . With the dramatic lowering of the piston down , ie under adiabatic expansion cooling the steam and it becomes supersaturated . In this state, the vapor is easily condensed. Condensation centers are ions formed flown at this time particle. So the camera appears foggy trail (track) (Fig. 3) , which can be observed and photographed. Track exists tenths of a second . Returning the piston to its original position and removing ions by the electric field , we can again perform adiabatic expansion . Thus , the experiments with the camera can be carried out repeatedly .

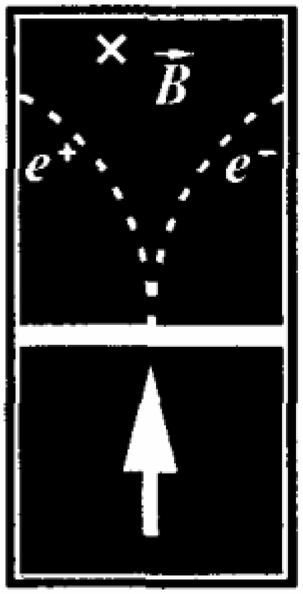


Рис. 4

If the camera is placed between the poles of an electromagnet, the capabilities of the camera to study the properties of the particles is greatly enhanced. In this case, the moving particle Lorentz force that makes it possible to determine the value of the curvature of the trajectory of the particle charge and momentum. Figure 4 shows a possible variant of decoding pictures of electron and positron tracks. Induction vector in the magnetic field directed perpendicular to the plane of the drawing in the drawing. Left rejected positron right - electron.

3) The bubble chamber

Differs from the cloud chamber that supersaturated vapors in the working volume

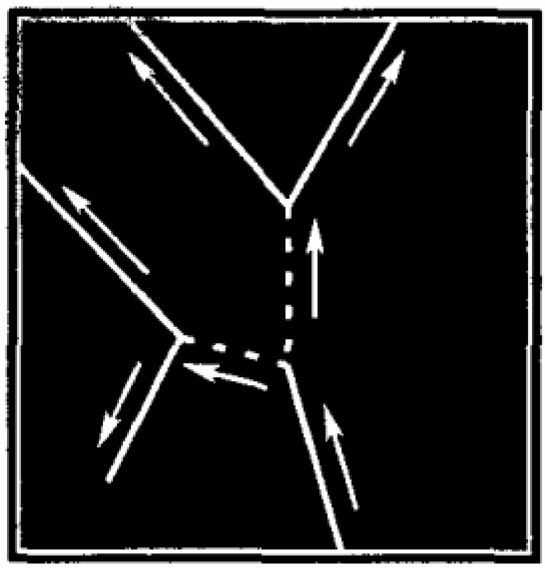


Рис. 5

of the chamber replaced superheated liquid, ie a fluid which is under pressure , the smaller its saturated vapor pressure .

Flying in such liquid particles cause the occurrence of vapor bubbles , thereby forming a track (Fig. 5).

In the initial state, the piston compresses the fluid. With a sharp decrease in pressure the boiling point of the liquid is less than the ambient temperature.

The liquid goes into the unstable (superheated) state. This provides the appearance of bubbles in the path of the particle. The working mixture was applied hydrogen, xenon, propane, and some other substances .

The advantage of the bubble chamber before expansion chamber due to the greater density of the working substance . Runs particles consequently are quite short and even high-energy particles get stuck in the chamber. This allows us to observe a series of successive transformations of the particle , and the resulting reaction.

4) Method of thick emulsions

For the detection of particles along with cloud chambers and bubble chambers used Thick emulsion . Ionizing effect of fast charged particles to the emulsion of the photographic plate . Emulsion contains a large number of microscopic crystals of silver bromide .

Fast charged particle,piercing crystal,removes electrons from individual atoms of bromine. Chain of such crystals form a latent image.When you are in these crystallites recovering metallic silver chain and silver grains forms a particle track .Length and thickness can be estimated track energy and mass of the particle . Because of the high density of the emulsion obtained very short tracks , but when photographing them can be increased. The advantage of the emulsion is that the exposure time can be arbitrarily large . This allows to register a rare phenomenon. It is also important that due to the high braking ability emulsion increases the number of interesting reactions between particles and nuclei.

Accelerators

Particle accelerator - a class of devices for charged particles(elementary particles, ions) at high energies. Modern accelerators , sometimes , are huge expensive complexes that can not afford even a big state . For example, the Large Hadron Collider at CERN is a ring of nearly 27 kilometers.

The operation of the accelerator incorporated the interaction of charged particles with electric and magnetic fields . Electric field can directly do work on the particle , that is, to increase its energy. The magnetic field , creating a Lorentz force only deflects the particle without changing its energy , and sets the orbit at which the particles move .

Structurally boosters can essentially be divided into two large groups. This linear accelerators , where the particle beam passes once accelerating gaps and circular accelerators , in which beams move along closed curves (such as circles) , passing the accelerating gap many times . Can also be classified by purpose accelerators : colliders , neutron sources , boosters , synchrotron radiation sources and devices for cancer therapy , industrial accelerators .

The high-voltage accelerator (accelerator direct action).Ideologically, the most simple, linear accelerator . Particles are accelerated by a constant electric field and move in straight lines on the vacuum chamber , which is located along the accelerating electrodes .

Acceleration of charged particles is an electric field , constant or slightly changing during the time of particle acceleration . An important advantage of the high-voltage amplifier is compared with other types of accelerators, - possibility of obtaining small energy spread in the particles accelerated into the time constant and uniform electric field. This type of accelerator is characterized by high efficiency (up to 95%) and the ability to create a relatively simple installations of high power (500 kW and up) , which is very important when using accelerators for industrial purposes.

High boosters can be divided into four groups according to the type of generators, generating high voltage :

• Van de Graaf accelerator . Accelerating voltage generator creates Van de Graaf , based on the mechanical charge transfer insulating tape. In modern versions (pelletronah) ribbon chain replaced . Maximum power voltage of ~ 20 MW determine the maximum particle energy of ~ 20 MeV.

• Cascade accelerator . Accelerating voltage creates a cascade generator (eg , Cockcroft -Walton generator , which creates a constant accelerating high voltage ~ 5 MW , converting low AC voltage on the diode multiplier circuit .)

• Transformer accelerator .High AC voltage generates a high voltage transformer , and the beam passes in the correct phase of the electric field near the maximum .

• Pulse accelerator . High voltage pulse transformer is created by discharging a large number of capacitors.

Linear induction accelerator

Acceleration in this type of machine is solenoidal electric field which is created with ferrimagnetic ring windings arranged along the beam axis.

Linear resonance accelerator

Also often called LINAC (short LINear ACcelerator). Accelerating high frequency electric field occurs resonators. Linear accelerators are often used for the primary particle acceleration obtained with an electron gun and ion source . However , the idea of linear colliders for the total energy is not new . The main advantage is the possibility of obtaining Linkov ultralow emittance and lack of radiation energy losses , which increase in proportion to the fourth power of the particle energy.

orbital accelerator

betatron

Cyclic accelerator in which particles are accelerated by the electric field provided by the vortex induced by a change in magnetic flux covered by the beam orbit . Since the creation of the vortex electric field is necessary to change the magnetic field of the core , and the magnetic field in the non-superconducting machines are generally limited effects of iron saturation level ~ 20kGs , there an upper limit on the maximum energy of the betatron . Betatrons primarily used to accelerate electrons to energies of 10-100 MeV (maximum reached in the betatron energy of 300 MeV) .

First betatron was designed and developed Wideröe in 1928, which, however , he could not run . The first reliable working betatron was created DV Kerst only in 1940-1941 . U.S. .

cyclotron

In a cyclotron particle injected near the center of the magnet with a uniform field with a small initial velocity. Further, the particles rotate in the magnetic field along the circumference inside the two hollow electrodes Sc. dees to which an alternating voltage . Particle is accelerated by the electric field of each turn in the gap between the dees . For this it is necessary to change the frequency of the voltage polarity on the dees was equal to the conversion rate of the particle. In other words, is the cyclotron resonance accelerator. It is clear that with increasing energy of the particle trajectory radius will increase until it will not go beyond the magnet.

Cyclotron - the first of cyclic accelerators . It was first designed and built in 1930 by Lawrence and Livingston , for which the first was awarded the Nobel Prize in

1939. Until now, cyclotrons are used to accelerate heavy particles to relatively low energies up to 50 MeV / nucleon .

Microtron

He - the accelerator with variable multiplicity . Resonant cyclic accelerator with constant like cyclotron guiding magnetic field and the frequency of the accelerating voltage . Microtron idea is to make the time increment turnover particles obtained by accelerating the turnover of each multiple of the oscillation period of the accelerating voltage .

FFAG

Accelerator with a constant (as in a cyclotron), but non-uniform field , and the variable frequency of the accelerating field .

Fazotron (synchrocyclotron)

The principal difference from the cyclotron - changeable during acceleration frequency electric field. This allows , at the expense of phase stability , raise the maximum energy of the accelerated ions is compared with the limit value for the cyclotron . Energy in Fazotron reaches 600-700 MeV.

synchrophasotron

Cyclic accelerator with constant length of the equilibrium orbit . To accelerate the particles in the process remained the same orbit as the master change the magnetic field and the frequency of the accelerating electric field.

synchrotron

Cyclic accelerator with constant length of the orbit and a constant frequency of the accelerating electric field, but changing a guiding magnetic field .

Accelerator - recuperator

In essence - this colt , but after using the beam is not reset and sent to the accelerating structure in the "wrong" phase and slows down, giving back energy. In addition, there are boosters multipass - recuperators, where the beam , on the basis of the microtron , makes several passes through the accelerating structure (possibly - on different tracks),first picking up the energy , and then returning it .

Accelerators diversion

Free electron laser (FEL)

Specialized source of coherent X-ray radiation.

collider

He collider . Purely experimental facilities whose purpose - to study the processes of particle collisions at high energies.

application

• Research
• Sterilization (for sterilization of food, medical instrument)
• Medicine (cancer treatment , X-ray diagnostics)
• Production of semiconductor devices (injection of impurities)
• Radiation flaw
• Radiation crosslinking of the polymers
• Radiation treatment of flue gases and waste water

Antiparticles . Discovery of the positron

Antiparticle - particle - double of some other elementary particle having the same mass and the same spin , but differing from it marks some characteristics of the interaction (charges such as electric and color charges , baryon and lepton quantum numbers) .

The very definition of what is called a "particle" in the particle-antiparticle pair , largely arbitrary . However, for a given choice of a "particle " of its antiparticle is uniquely determined. Baryon number conservation in weak interaction allows for baryon decay chain to determine the " particle" in any pair of baryon- antibaryon . Selecting the electron as a "particle" in a pair of electron-positron captures (due to lepton number conservation in weak interactions) to determine the state of a "particle " in a pair of electron neutrino - antineutrino. Transitions between different generations of leptons (type) were not observed , so that the definition of "particles" in each generation of leptons , generally speaking, can be produced independently. Usually , by analogy with the electron " particles" called negatively charged leptons that if the lepton number identifies the relevant neutrinos and antineutrinos . Bosons term " particle" can be fixed definition , for example, the hypercharge .

the existence of antiparticles

The existence of antiparticles was predicted by PAM Dirac . He had received in 1928 a quantum relativistic equation of motion of the electron (the Dirac equation) with the need to contain solutions with negative energies . It was subsequently shown that the disappearance of the electron with negative energy should be interpreted as the occurrence of particles (of the same mass) with positive energy and a positive electric charge , ie, the antiparticle to the electron . This particle - the positron - was opened in 1932.

In subsequent experiments it was found that not only the electron but also all the particles have their antiparticle. In 1936, cosmic rays were discovered muon (m -) and m + its antiparticle , and in 1947 - p and p + - mesons constituting a pair particle - antiparticle , in 1955 in experiments on antiproton accelerator registered in 1956 - antineu etc. To date antiparticles observed virtually all known particles , and there is no doubt that antiparticles are all particles.

Truly neutral particles

For some neutral particle antiparticle is identical to the particle.This, in particular , the photon , neutral pi-meson , the meson and other quarkonia,the Higgs boson , Z-boson , the graviton . Such particles are called truly neutral.We emphasize that the electrically neutral particles do not necessarily coincide with their antiparticles . This particularly applies to the neutron neutrino neutral kaon ,etc.

All known truly neutral particles - bosons , but in principle there may be truly neutral fermions (the so-called . Majorcan particles).

Creation and annihilation

Antiparticles birth occurs in collisions of particles of matter accelerated to energies exceeding the threshold of the particle-antiparticle pairs (see Pair) . Under laboratory conditions, the antiparticles are produced in the interactions of particles in accelerators , storage produced antiparticles performed in storage rings under high vacuum . In vivo anti-particles are produced in the interaction of primary cosmic rays with matter , such as the Earth's atmosphere , and should be produced in the vicinity of pulsars and active galactic nuclei . Theoretical Astrophysics considered education antiparticles (positrons , anti-nucleons) for accretion onto black holes . Within the framework of modern cosmology is considered the birth of antiparticles by evaporation of primordial black holes of small mass. At temperatures above the rest energy of the particles of the class (in the energy system of units) , particle-antiparticle pairs are present in equilibrium with matter and electromagnetic radiation . Such conditions can be realized for the electron-positron pairs in the hot cores of massive stars . According to the hot universe theory , in the very early stages of the expansion of the universe in equilibrium with matter and radiation were particle-antiparticle pairs of all kinds. According to models of grand unification effects of C - and CP- invariance in nonequilibrium processes with no conservation of baryon number could result in the very early universe to the baryon asymmetry of the universe , even in conditions of strict equality of the initial number of particles and antiparticles. This gives a physical justification for the lack of observational data on the existence of objects in the universe of antiparticles.

In the collision of a particle with its antiparticle possible their annihilation .

Positron (from the English . Positive - positive) - the antiparticle of the electron. Refers to antimatter , one has an electric charge , spin 1/2, -1 lepton charge and mass of the electron mass . When an electron positron annihilation , their mass is converted into energy in the form of two (or much less - three or more) of gamma rays .

The positrons having one type of radioactive decay (positron emission) , and the interaction of photons with an energy of 1.022 MeV and greater substance. The latter process is called " pair production " because when implementing the photon interacts with the electromagnetic field of the nucleus , forming both the electron and positron . Also positrons can arise in the process of electron-positron pairs in a strong electric field.

Opening

Existence of the positron was first proposed in 1928 [1] by Paul Dirac . Dirac's theory describes not only the electron with a negative electrical charge , but similar particle with a positive charge . The absence of such particles in nature was seen as an indication of the " extraneous solutions " Dirac equations . But the discovery of the positron was a triumph of the theory .

In accordance with the theory of the Dirac electron and positron pair can be produced , and this process must be expended energy equal to the rest energy of the particles , 2CH0 , 511 MeV. Because they were known natural radioactive substances emitted g rays with energy greater than 1 MeV positrons been possible to obtain in a laboratory, which was done . An experimental comparison of the properties of the electrons and positrons showed that all of the physical characteristics of the particles except the sign of the electric charge are the same

Positron was discovered in 1932 by American physicist Andersen when observing cosmic radiation using cloud chamber placed in a magnetic field. The name " positron " Anderson invented himself . Interestingly, Anderson also proposed , unsuccessfully , to rename the electrons in " negatrons ." He photographed the tracks of particles that are very reminiscent of the electron tracks , but had a bend under the influence of a magnetic field opposite to the electron track , indicating a positive electric charge of the particles detected . Soon after this discovery , also by means of a cloud chamber photographs were obtained , sheds light on the origin of positrons : under the influence of g - quanta of secondary cosmic ray positrons are born in pairs with ordinary electrons. Such properties of the newly discovered particles were in striking agreement with the already existing theory of relativistic Dirac electron . In 1934, Irene and Frederic Joliot-Curie in France discovered another source of positrons - in + - radioactivity.

Positron appeared first open antiparticle . The existence of antiparticles and the corresponding total electron properties of two antiparticles Dirac theory conclusions that could be generalized to other particles , suggested the possibility of steamy nature of elementary particles and subsequent physical oriented research. This orientation proved to be extremely fruitful , and is currently paired nature of elementary particles is exactly the statutory nature, founded a large number of experimental facts.

Annihilation

Of Dirac's theory implies that the electron and positron in a collision must annihilate with release of energy , equal to the total energy of the colliding particles. It turned out that this process occurs mainly after braking positron in matter when the total energy of the two particles is equal to their rest energy of 1.022 MeV. On experience were registered couples g rays with an energy of 0.511 MeV emitted in opposite directions from a target irradiated by positrons. When the need of electron and positron annihilation of not one but at least two g - rays follows from the law of conservation of momentum . Total momentum of the center of mass to the positron and electron conversion process is zero, but if in the annihilation occurs only one g - quantum, he was carrying to the momentum that is not equal to zero in any frame of reference .

Since 1951 it is known that in some amorphous solids , liquids and gases positron after braking in a significant number of cases did not immediately annihilated , but forms a short time associated with electronic systems , called positronium . Positronium in terms of their chemical properties similar to the hydrogen atom , as it is a system consisting of a single positive and negative electric charges , and can enter into chemical reactions . Since the electron and positron - different particle, then a state associated with the lowest energy , they may be not only antiparallel but with parallel spins. In the first case, the total spin of positronium s = 0 , which corresponds to the para- and the second - s = 1 , which corresponds to ortho-positronium . Interestingly, the annihilation of electron -positron pair comprising Orthopositronium not be accompanied by the birth of two g - rays . Two g - quantum carry each other mechanical moments equal to 1 , and can make full time equal to zero, but not unity. Therefore, in this case the annihilation accompanied by the emission of three g - rays with a total energy of 1.022 MeV. Education Orthopositronium three times more likely than positronium , as the ratio of the statistical weights (2s +1) both positronium states 3:1. However, even in the bodies of a large percentage (50%) in the annihilation of the bound state , ie, after the formation of positronium , mainly there are two g -quantum and only very rarely three.[15]

Analyzing the study of elementary particle physics section in continuing education to the following conclusions:

In academic lyceums directions exact and natural sciences in the study of elementary particle physics is necessary to use slides and animations showing virtual laboratory processes involving elementary particles with the widely used of computer technology. Extensive use of computer technology ensures clarity of printed educational process and help to better master the subject.

3. Examining the status of teaching about the "Elementary particles" in in higher education.

Studied physics in higher schools 612 hours on 3 course . " Elementary Particle Physics " in higher schools direction of exact sciences studied 68 hours. In the areas of exact sciences contents of this section are as follows: “Structure atomic nucleus. Charge of the atom, weight of atomic nucleus, the radius of the atomic nucleus”, “Nuclear forces and their properties. Nuclear spins and nuclear moments”, “Nuclear models”, “Planetary model of the atom”, “Radioactivity”, “Alpha radioactivity” , “Beta decay. Types of beta decay, energy spectra of beta

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[15] Baudis L. Dark matter searches. Proc. of the XXII Int. Symp. "Lepton and Photon Interactions at High Energies". Uppsala University, Sweden, 30 june- 5 July, 2005 .-P.350- 363.

decay", "Neutron", "Gamma decay. Nuclear isomerism", "Nuclear reaction. Conservation laws of nuclear reactions. Mechanism of nuclear reactions" , "Elementary particles. Classification of elementary particles. Quark model of elementary particles" , "Radiation dosimetry nuclei" , "Quantum theory of the hydrogen atom" , "Angular and radial part of the Schrödinger equation" , "Electron Orbit Magnetic Moment" , " Electron spin" , "Mechanical and magnetic moments of atoms" , "The Pauli principle".

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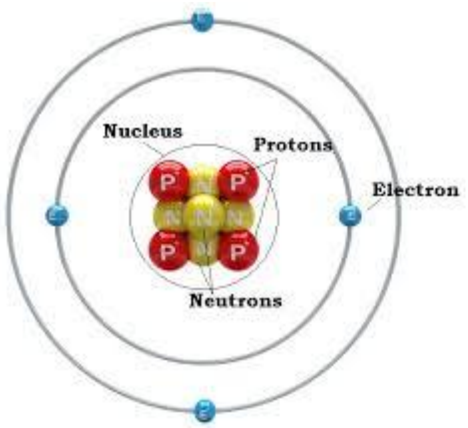
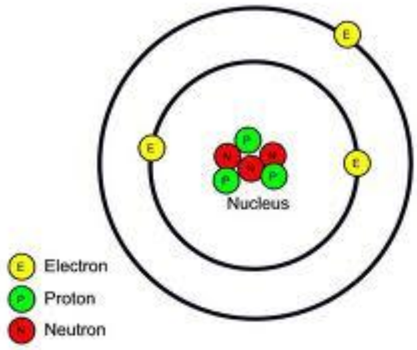
Structure atomic nucleus. Charge of the atom, weight of atomic nucleus, the radius of the atomic nucleus.





The nucleus is the very dense region consisting of protons and neutrons at the center of an atom. It was discovered in 1911 as a result of Ernest Rutherford's interpretation of the 1909 Geiger–Marsden gold foil experiment performed by Hans Geiger and Ernest Marsden under Rutherford's direction. The proton–neutron model of nucleus was proposed by Dmitry Ivanenko in 1932. Almost all of the mass of an atom is located in the nucleus, with a very small contribution from the electron cloud.

The diameter of the nucleus is in the range of 1.75 fm ($1.75\times10{-}15$ m) for hydrogen (the diameter of a single proton) to about 15 fm for the heaviest atoms, such as uranium. These dimensions are much smaller than the diameter of the atom itself (nucleus + electron cloud), by a factor of about 23,000 (uranium) to about 145,000 (hydrogen).

The branch of physics concerned with studying and understanding the atomic nucleus, including its composition and the forces which bind it together, is called nuclear physics.

The nucleus was discovered in 1911, as a result of Ernest Rutherford's efforts to test Thomson's "plum pudding model" of the atom. The electron had already been discovered earlier by J.J. Thomson himself, and knowing that atoms are neutral, Thomson postulated that there must be a positive charge as well. In his plum pudding model, Thomson stated that an atom consisted of negative electrons randomly scattered within a sphere of positive charge. Ernest Rutherford later devised an experiment that involved the deflection of alpha particles at a thin sheet of metal foil. He reasoned that if Thomson's model were correct, the immense alpha particles would easily pass through the foil with very little deviation in their paths. To his surprise, many of the particles were deflected at very large angles. Because the mass of alpha particles is about 8000 times that of an electron, it became apparent that a very strong force was present that allowed the particles to be deflected. He realized that the plum pudding model could not be accurate and that the deflections of the alpha particles could only be caused by a center of concentrated charge that contained most of the atom's mass. Thus, the idea of a nuclear atom—an atom with a dense center of positive charge—became justified.

The term nucleus is from the Latin word nucleus, a diminutive of nux ("nut"), meaning the kernel (i.e., the "small nut") inside a watery type of fruit (like a peach). In 1844, Michael Faraday used the term to refer to the "central point of an atom". The modern atomic meaning was proposed by Ernest Rutherford in 1912. The adoption of the term "nucleus" to atomic theory, however, was not immediate. In 1916, for example, Gilbert N. Lewis stated, in his famous article The Atom and the Molecule, that "the atom is composed of the kernel and an outer atom or shell".

The nucleus of an atom consists of protons and neutrons (two types of baryons) bound by the nuclear force (also known as the residual strong force). These baryons are further composed of subatomic fundamental particles known as quarks bound by the strong interaction. Which chemical element an atom represents is determined by the number of protons in the nucleus. Each proton carries a single positive charge, and the total electrical charge of the nucleus is spread fairly uniformly throughout its body, with a fall-off at the edge.

Major exceptions to this rule are the light elements hydrogen and helium, where the charge is concentrated most highly at the single central point (without a central volume of uniform charge). This configuration is the same as for 1s electrons in atomic orbital's, and is the expected density distribution for fermions (in this case, protons) in 1s states without orbital angular momentum.

As each proton carries a unit of charge, the charge distribution is indicative of the proton distribution. The neutron distribution probably is similar.

While protons define the entire charge of a nucleus and, hence, its chemical identity, neutrons are electrically neutral, but contribute to the mass of a nucleus to the same extent. Neutrons explain the phenomenon of isotopes – varieties of a chemical element which differ in atomic mass.[16]

Nuclear forces and their properties. Nuclear spins and nuclear moments

The nuclear force (or nucleon–nucleon interaction or residual strong force) is the force between two or more nucleons. Its fundamental laws and constants are unknown unlike the Coulomb and Newton laws. It is responsible for binding protons and neutrons into atomic nuclei. The energy released by such binding causes the masses of nuclei to be less than the total mass of the protons and neutrons which form them; this is the energy used in nuclear power and nuclear

[16] Okun L.B. Elementary particle physics . - Moscow: Nauka , 1988. - 272 .

weapons. The force is powerfully attractive between nucleons at distances of about 1 femtometer (fm) between their centers, but rapidly decreases to insignificance at distances beyond about 2.5 fm. At very short distances less than 0.7 fm, it becomes repulsive, and is responsible for the physical size of nuclei, since the nucleons can come no closer than the force allows.

The nuclear force is now understood as a residual effect of the even more powerful strong force, or strong interaction, which is the attractive force that binds particles called quarks together, to form the nucleons themselves. This more powerful force is mediated by particles called gluons, which are a type of gauge boson. Gluons hold quarks together with a force like that of electric charge, but of far greater power.

The concept of a nuclear force was first quantitatively constructed in 1934, shortly after the discovery of the neutron revealed that atomic nuclei were made of protons and neutrons, held together by an attractive force. The nuclear force at that time was conceived to be transmitted by particles called mesons, which were predicted in theory before being discovered in 1947. In the 1970s, further understanding revealed these mesons to be combinations of quarks and gluons, transmitted between nucleons that themselves were made of quarks and gluons. This new model allowed the strong forces that held nucleons together, to be felt in neighboring nucleons, as residual strong forces.

The nuclear forces arising between nucleons are now seen to be analogous to the forces in chemistry between neutral atoms or molecules called London forces. Such forces between atoms are much weaker than the attractive electrical forces that hold the atoms themselves together (i.e., that bind electrons to the nucleus), and their range between atoms is shorter, because they arise from small separation of charges inside the neutral atom. Similarly, even though nucleons are made of quarks in combinations which cancel most gluon forces (they are "color neutral"), some combinations of quarks and gluons nevertheless leak away from nucleons, in the form of short-range nuclear force fields that extend from one nucleon to another nucleon that is close by. These nuclear forces are very weak compared to direct gluon forces ("color forces" or strong forces) inside nucleons, and the nuclear forces extend only over a few nuclear diameters, falling exponentially with distance. Nevertheless, they are strong enough to bind neutrons and protons over short distances, and overcome the electrical repulsion between protons in the nucleus.

Like London forces, nuclear forces also stop being attractive and become repulsive, when nucleons are brought too close together.

The nuclear force has been at the heart of nuclear physics ever since the field was born in 1932 with the discovery of the neutron by James Chadwick. The traditional goal of nuclear physics is to understand the properties of atomic nuclei in terms of the 'bare' interaction between pairs of nucleons, or nucleon–nucleon forces (NN forces).[17]

In 1934, Hideki Yukawa made the earliest attempt to explain the nature of the nuclear force. According to his theory, massive bosons (mesons) mediate the interaction between two nucleons. Although, in light of quantum chromodynamics (QCD), meson theory is no longer perceived as fundamental, the meson-exchange concept (where hadrons are treated as elementary particles) continues to represent the best working model for a quantitative NN potential.

Historically, it was a formidable task to describe the nuclear force phenomenological, and the first semi-empirical quantitative models came in the mid-1950s. There has been substantial progress in experiment and theory related to the nuclear force. Most basic questions were settled in the 1960s and 1970s. In recent years, experimenters have concentrated on the subtleties of the nuclear

[17] Mukhin K.I. Elementary particle physics . In 2 t.-M. : Nauka, 1985 . V.2 . - 358 p.

force, such as its charge dependence, the precise value of the πNN coupling constant, improved phase shift analysis, high-precision NN data, high-precision NN potentials, NN scattering at intermediate and high energies, and attempts to derive the nuclear force from QCD.

To a large extent, the nuclear force can be understood in terms of the exchange of virtual light mesons, such as the virtual peons, as well as two types of virtual mesons with spin (vector mesons), the rho mesons and the omega mesons. The vector mesons account for the spin-dependence of the nuclear force in this "virtual meson" picture.

Sometimes, the nuclear force is called the residual strong force, in contrast to the strong interactions which are now understood to arise from QCD. This phrasing arose during the 1970s when QCD was being established. Before that time, the strong nuclear force referred to the inter-nucleon potential. After the verification of the quark model, strong interaction has come to mean QCD.

The nuclear force is only felt among hadrons. At small separations between nucleons (less than ~ 0.7 fm between their centers, depending upon spin alignment) the force becomes repulsive, which keeps the nucleons at a certain average separation, even if they are of different types. This repulsion is to be understood in terms of the Pauli exclusion force for identical nucleons (such as two neutrons or two protons), and also a Pauli exclusion between quarks of the same type within nucleons, when the nucleons are different (a proton and a neutron, for example). As will be discussed, the nuclear force also has a "tensor" component which depends on whether or not the spins of the nucleons are aligned or anti-aligned.[clarification needed] A graph of internuclear forces and potentials is presented in the reference:

At distances larger than 0.7 fm the force becomes attractive between spin-aligned nucleons, becoming maximal at a center–center distance of about 0.9 fm. Beyond this distance the force drops essentially exponentially, until beyond about 2.0 fm separation, the force drops to negligibly small values.

At short distances (less than 1.7 fm or so), the nuclear force is stronger than the Coulomb force between protons; it thus overcomes the repulsion of protons inside the nucleus. However, the Coulomb force between protons has a much larger range due to its decay as the inverse square of charge separation, and Coulomb repulsion thus becomes the only significant force between protons when their separation exceeds about 2 to 2.5 fm.

To disassemble a nucleus into unbound protons and neutrons would require doing work against the nuclear force. Conversely, energy is released when a nucleus is created from free nucleons or other nuclei: the nuclear binding energy. Because of mass–energy equivalence (i.e. Einstein's famous formula E = mc2), releasing this energy causes the mass of the nucleus to be lower than the total mass of the individual nucleons, leading to the so-called "mass deficit".

The nuclear force is nearly independent of whether the nucleons are neutrons or protons. This property is called charge independence. It depends on whether the spins of the nucleons are parallel or ant parallel, and has a no central or tensor component. This part of the force does not conserve orbital angular momentum, which is a constant of motion under central forces.

The symmetry resulting in the strong force was first proposed by Werner Heisenberg. In essence, this is that protons and neutrons are identical in every respect other than their charge. This is not completely true, because neutrons are a tiny bit heavier, so it is an approximate symmetry. Under Heisenberg's symmetry, both protons and neutrons are termed as nucleons with different isospin. The strong force is invariant under SU(2) transformations, just as particles with "regular spin" are isospin and "regular" spin are related under this SU(2) symmetry group. There are only strong attractions when the total isospin is 0, as is confirmed by experiment.

The info on nuclear force are obtained by scattering experiments and the study of light nuclei binding energy.

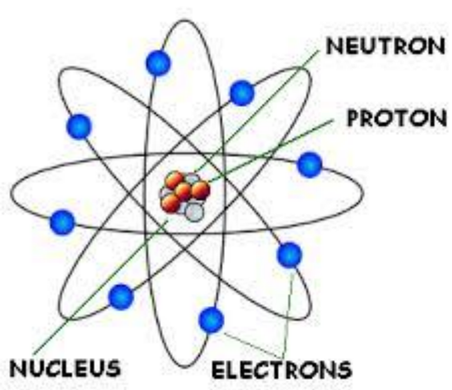
It is common practice to represent the total angular momentum of a nucleus by the symbol I and to call it "nuclear spin". For electrons in atoms we make a clear distinction between electron spin and electron orbital angular momentum, and then combine them to give the total angular momentum. But nuclei often act as if they are a single entity with intrinsic angular momentum I. Associated with each nuclear spin is a nuclear magnetic moment which produces magnetic interactions with its environment.

The nuclear spins for individual protons and neutrons parallels the treatment of electron spin, with spin 1/2 and an associated magnetic moment. The magnetic moment is much smaller than that of the electron. For the combination neutrons and protons into nuclei, the situation is more complicated.

A characteristic of the collection of protons and neutrons (which are fermions) is that a nucleus of odd mass number A will have a half-integer spin and a nucleus of even A will have integer spin. The suggestion that the angular momenta of nucleons tend to form pairs is supported by the fact that all nuclei with even Z and even N have nuclear spin I=0. For example, in the nuclear data table for iron below, all the even A nuclides have spin I=0 since there are even numbers of both neutrons and protons. The half-integer spins of the odd-A nuclides suggests that this is the nuclear spin contributed by the odd neutron.

Nuclear models.

The structure of atoms is now well understood: quantum physics governs all; the electromagnetic force is the main force; each atom contains a massive force center (the nucleus) that tends to dominate the physics. However, things are not in such a happy state for the nucleus. Quantum mechanics still governs its behavior, but the forces are complicated and cannot, in fact, be written down explicitly in full detail.



We are dealing with a many-body problem of great complexity.

So, in the absence of a comprehensive nuclear theory, we turn to the construction of nuclear models. A nuclear model is simply a way of looking at the nucleus that gives a physical insight into as wide a range of its properties as possible. The usefulness of a model is tested by its ability to provide predictions that can be verified experimentaly in the laboratory.

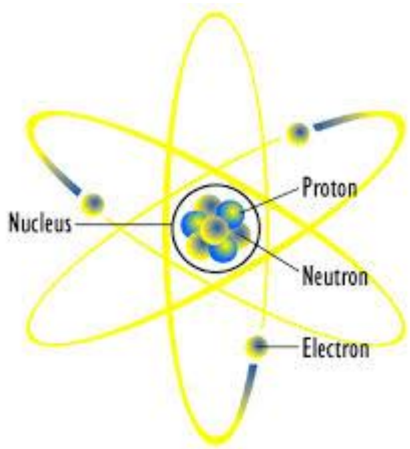
Two models of the nucleus have proved useful: the liquid drop model and the independent particle model. Although based on assumptions that seem flatly to exclude each other, each accounts very well for a selected group of nuclear properties. After describing them separately, we shall see how these two models may be combined to form a single coherent picture of the atomic nucleus known as the collective model.

In the liquid drop model, formulated by Niels Bohr, the nucleons are imagined to interact strongly with each other, like the molecules in a drop of liquid. A given nucleon collides frequently with other nucleons in the nuclear interior, its mean free path as it moves about being substantially less than the nuclear radius. This constant "jiggling around" reminds us of the thermal agitation of the molecules in a drop of liquid. The liquid drop model permits us to correlate many facts about nuclear masses and binding energies; it is useful in explaining nuclear fission. It also provides a useful model for understanding a large class of nuclear reactions.

If we consider the sum of the following three types of energies, then the picture of a nucleus as a drop of liquid accounts for the observed variation of binding energy per nucleon with mass number:

- Volume Energy - Because each bond energy is shared by two nucleons, each has a binding energy of one-half that. When an assembly of spheres of the same size is packed together into the smallest volume, as we suppose is the case of nucleons within a nucleus, each interior sphere has 12 other spheres in contact with it. So, this energy is proportional to the volume.
- Surface Energy - A nucleon at the surface of a nucleus interacts with fewer other nucleons that one in the interior of the nucleus and hence its binding energy is less. This surface energy takes that into account and is therefore negative.

- Coulomb Energy - The electric repulsion between each pair of protons in a nucleus also contributes toward decreasing its binding energy. The coulomb energy of a nucleus is equal to the work that must be done to bring together the protons from infinity into a spherical aggregate the size of the nucleus. The coulomb energy is negative because it arises from an effect that opposes nuclear stability.



In the liquid drop model, we assume that the nucleons move around at random and bump into each other frequently. The independent particle model, however, is based on just the opposite assumption, namely, that each nucleon moves in a well-defined orbit within the nucleus and hardly makes any collisions at all! A nucleon in a nucleus, like an electron in an atom, has a set of quantum numbers that defines its state of motion. also, nucleons obey the Pauli exclusion principle, just as electrons do.That is, no two nucleons may occupy the same state at the same time. In this regard, the neutrons and the protons are treated separately, each having its own array of available quantized states.

The fact that nucleons obey the Pauli exclusion principle helps us to understand the relative stability of nucleon states. If two nucleons within the nucleus are to collide, the energy of each of them after the collision must correspond to the energy of an unoccupied state. If these states are filled, the collision simply cannot take place. In time, any given nucleon will undergo a possible collision, but meanwhile it will have made enough revolutions in its orbit to give meaning to the notion of a nucleon state with a quantized energy.

In the atomic realm, the repetitions of physical and chemical properties that we find in the periodic table are associated with the fact that the atomic electrons arrange themselves in shells that have a special stability when fully occupied. We can take the atomic numbers of the noble gases, 2, 10, 18, 36, 54, 86, ... as magic electron numbers that mark the completion of such shells.

Planetary model of the atom

The Rutherford model is a model of the atom devised by Ernest Rutherford. Rutherford directed the famous Geiger-Marsden experiment in 1909 which suggested, upon Rutherford's 1911 analysis, that the so-called "plum pudding model" of J. J. Thomson of the atom was incorrect. Rutherford's new model for the atom, based on the experimental results, contained the new features of a relatively high central charge concentrated into a very small volume in comparison to the rest of the atom and with this central volume also containing the bulk of the atomic mass of the atom. This region would be named the "nucleus" of the atom in later years.

Rutherford overturned Thomson's model in 1911 with his well-known gold foil experiment in which he demonstrated that the atom has a tiny, heavy nucleus. Rutherford designed an experiment to use the alpha particles emitted by a radioactive element as probes to the unseen world of atomic structure.

Rutherford presented his own physical model for subatomic structure, as an interpretation for the unexpected experimental results. In it, the atom is made up of a central charge (this is the modern atomic nucleus, though Rutherford did not use the term "nucleus" in his paper) surrounded by a cloud of (presumably) orbiting electrons. In this May 1911 paper, Rutherford only commits himself to a small central region of very high positive or negative charge in the atom.

For concreteness, consider the passage of a high speed α particle through an atom having a positive central charge N e, and surrounded by a compensating charge of N electrons.

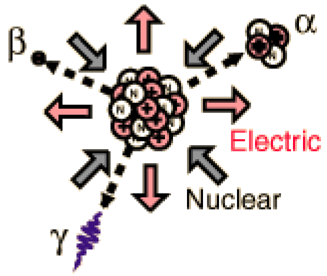
From purely energetic considerations of how far particles of known speed would be able to penetrate toward a central charge of 100 e, Rutherford was able to calculate that the radius of his gold central charge would need to be less (how much less could not be told) than 3.4 x 10−14 metres. This was in a gold atom known to be 10−10 meters or so in radius—a very surprising finding, as it implied a strong central charge less than 1/3000th of the diameter of the atom.

The Rutherford model served to concentrate a great deal of the atom's charge and mass to a very small core, but didn't attribute any structure to the remaining electrons and remaining atomic mass. It did mention the atomic model of Hantaro Nagaoka, in which the electrons are arranged in one or more rings, with the specific metaphorical structure of the stable rings of Saturn. The plum pudding model of J.J. Thomson also had rings of orbiting electrons. Jean Baptiste Perrin claimed in his Nobel Lecture that he was the first one to suggest the model in his paper dated 1901.

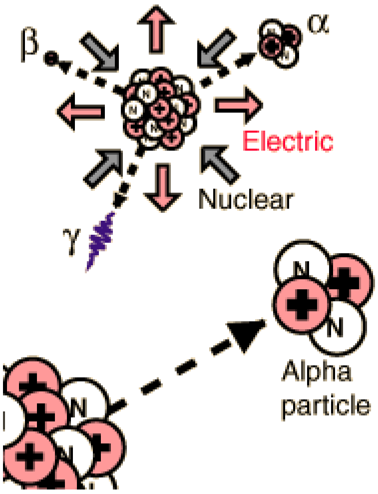
The Rutherford paper suggested that the central charge of an atom might be "proportional" to its atomic mass in hydrogen mass units u (roughly 1/2 of it, in Rutherford's model). For gold, this mass number is 197 (not then known to great accuracy) and was therefore modeled by Rutherford to be possibly 196 u. However, Rutherford did not attempt to make the direct connection of central charge to atomic number, since gold's "atomic number" (at that time merely its place number in the periodic table) was 79, and Rutherford had modeled the charge to be about + 100 units (he had actually suggested 98 units of positive charge, to make half of 196). Thus, Rutherford did not formally suggest the two numbers (periodic table place, 79, and nuclear charge, 98 or 100) might be exactly the same. A month after Rutherford's paper appeared, the proposal regarding the exact identity of atomic number and nuclear charge was made by Antonius van den Broek, and later confirmed experimentally within two years, by Henry Moseley.

Radioactivity

Radioactivity refers to the particles which are emitted from nuclei as a result of nuclear instability. Because the nucleus experiences the intense conflict between the two strongest forces in nature, it should not be surprising that there are many nuclear isotopes which are unstable and emit some kind of radiation. The most common types of radiation are called alpha, beta, and gamma radiation, but there are several other varieties of radioactive decay.



Radioactive decay rates are normally stated in terms of their half-lives, and the half-life of a given nuclear species is related to its radiation risk. The different types of radioactivity lead to different decay paths which transmute the nuclei into other chemical elements. Examining the amounts of the decay products makes possible radioactive dating.

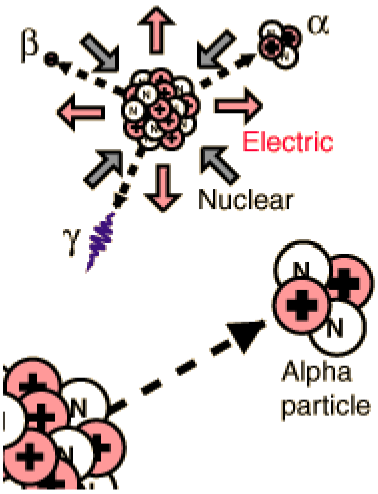


Radiation from nuclear sources is distributed equally in all directions, obeying the inverse square law.

Composed of two protons and two neutrons, the alpha particle is a nucleus of the element helium. Because of its very large mass (more than 7000 times the mass of the beta particle) and its charge, it has a very short range. It is not suitable for radiation therapy since its range is less than a tenth of a millimeter inside the body. Its main radiation hazard comes when it is ingested into the body; it has great destructive power within its short range. In contact with fast-growing membranes and living cells, it is positioned for maximum damage.

Alpha particle emission is modeled as a barrier penetration process. The alpha particle is the nucleus of the helium atom and is the nucleus of highest stability.

Alpha radioactivity



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Beta decay. Types of beta decay, energy spectra of beta decay.

In nuclear physics, beta decay (β decay) is a type of radioactive decay in which a beta particle (an electron or a positron) is emitted from an atomic nucleus. Beta decay is a process which allows the atom to obtain the optimal ratio of protons and neutrons.

Beta decay is mediated by the weak force. There are two types: beta minus and beta plus. In the case of beta decay that produces an electron emission, it is referred to as beta minus (β−), while in the case of a positron emission as beta plus (β+).

An example of β− decay is shown when carbon-14 decays into nitrogen-14:

14 6C → 14 7N + e − + ν e

Notice how, in electron emission, an electron antineutrino is also emitted. In this form of decay, the original element has decayed into a new element with an unchanged mass number A but an atomic number Z that has increased by one.

An example of positron (β+ decay) is shown with magnesium-23 decaying into sodium-23:

23 12Mg → 23 11Na + e+ + ν e

In contrast to electron emission, positron emission is accompanied by the emission of an electron neutrino. Similar to electron emission, positron decay results in nuclear transmutation, changing an atom of a chemical element into an atom of an element with an unchanged mass number. However, in positron decay, the resulting element has an atomic number that has decreased by one.

Emitted beta particles have a continuous kinetic energy spectrum, ranging from 0 to the maximal available energy (Q), which depends on the parent and daughter nuclear states that participate in the decay. The continuous energy spectra of beta

[18] Bugaev A.I. Methods of teaching physics in high school.Theoretical bases . M : Education, 1981 , c- 274

particle occurs because Q is shared between the beta particle and a neutrino.[1] A typical Q is around 1 MeV, but it can range from a few keV to a few tens of MeV. Since the rest mass energy of the electron is 511 keV, the most energetic beta particles are ultrarelativistic, with speeds very close to the speed of light.

Sometimes electron capture decay is included as a type of beta decay (and is referred to as "inverse beta decay"), because the basic process, mediated by the weak force is the same. However, no beta particle is emitted, but only an electron neutrino. Instead of beta-plus emission, an inner atomic electron is captured by a proton in the nucleus. An example of electron capture involves krypton-81 becoming bromine-81 and producing an electron neutrino:

$^{81}_{36}Kr + e^- \rightarrow ^{81}_{35}Br + \nu_e$

This type of decay is therefore analogous to positron emission (and also happens, as an alternative decay route, in all positron-emitters). However, the route of electron capture is the only type of decay that is allowed in proton-rich nuclides that do not have sufficient energy to emit a positron (and neutrino). These may still reach a lower energy state, by the equivalent process of electron capture and neutrino emission.

In β− decay, the weak interaction converts an atomic nucleus into a nucleus with one higher atomic number while emitting an electron (e^-) and an electron antineutrino (ν_e):$^{A}_{Z}N \rightarrow ^{A}_{Z+1}N' + e^- + \nu_e$

where A and Z are the mass number and atomic number of the decaying nucleus.

Another example is when the free neutron ($^{1}_{0}n$) decays by β− decay into a proton (p):$n \rightarrow p + e^- + \nu_e$.

At the fundamental level (as depicted in the Feynman diagram on the right), this is caused by the conversion of the negatively charged (−1⁄3 e) down quark to the positively charged (+2⁄3 e) up quark by emission of a W− boson; the W− boson subsequently decays into an electron and an electron antineutrino:

$d \rightarrow u + e^- + \nu_e$.   β− decay generally occurs in neutron-rich nuclei.

Neutron.

The neutron is a subatomic hadron particle that has the symbol n or n0. Neutrons have no net electric charge and a mass slightly larger than that of a
proton. With the exception of hydrogen-1, the nucleus of every atom consists of at least one or more of both protons and neutrons. Protons and neutrons are collectively referred to as "nucleons". Since interacting protons have a mutual electromagnetic repulsion that is stronger than their attractive nuclear interaction, neutrons are often a necessary constituent within the atomic nucleus that allows a collection of protons to stay atomically bound (see diproton & neutron-proton ratio).Neutrons bind with protons and one another in the nucleus via the nuclear force, effectively stabilizing it. The number of neutrons in the nucleus of an atom is referred to as its neutron number, which reveals the specific isotope of that atom. For example, the abundant carbon-12 isotope has 6 protons and 6 neutrons, whereas the rare radioactive carbon-14 isotope also has 6 protons but, instead, 8 neutrons. Elements may be found in nature as only one isotope or with as many as 10 isotopes (Manganese and Tin, respectively).

While the bound neutrons in nuclei can be stable (depending on the nuclide), free neutrons are unstable; they undergo beta decay with a mean lifetime of just under 15 minutes (881.5±1.5 s).Free neutrons are produced in nuclear fission and fusion. Dedicated neutron sources like neutron generators, research reactors and spallation sources produce free neutrons for use in irradiation and in neutron scattering experiments. Even though it is not a chemical element, the free neutron is sometimes included in tables of nuclides.

The neutron has been key to the production of nuclear power. The neutron was discovered in 1932, and in 1933, it was realized that it might mediate a nuclear chain reaction. In the 1930s, neutrons were used to produce many different types of nuclear transmutations. When nuclear fission was discovered in 1938, it became clear that, if the process also produced neutrons, this might be the mechanism to produce the neutrons for a chain reaction. This was proven in 1939, opening the path to nuclear power production. These events and findings led directly to the first self-sustaining, man-made, nuclear chain reaction (Chicago Pile-1, 1942) and to the first nuclear weapons (1945).

In 1920, Ernest Rutherford conceived the possible existence of the neutron.In particular, Rutherford considered that the disparity found between the atomic number of an atom and its atomic mass could be explained by the existence of a neutrally charged particle within the atomic nucleus. He considered the neutron to be a neutral double consisting of an electron orbiting a proton.

Through the 1920s, physicists had generally accepted an (incorrect) model of the atomic nucleus as composed of protons and electrons. It was known that atomic nuclei usually had about half as many positive charges than if they were composed completely of protons, and in existing models this was often explained by proposing that nuclei also contained some "nuclear electrons" to neutralize the excess charge. Thus, the nitrogen-14 nucleus would be composed of 14 protons and 7 electrons to give it a charge of +7 but a mass of 14 atomic mass units.

The new quantum mechanics implied that a particle as light as the electron could not be contained in a region as small as the nucleus with any reasonable energy. In 1930 Viktor Ambartsumian and Dmitri Ivanenko in the USSR found that, contrary to the prevailing opinion of the time, the nucleus cannot consist of protons and electrons. They proved that some neutral particles must be present besides the protons.

In 1931, Walther Bothe and Herbert Becker in Germany found that if the very energetic alpha particles emitted from polonium fell on certain light elements, specifically beryllium, boron, or lithium, an unusually penetrating radiation was produced. At first this radiation was thought to be gamma radiation, although it was more penetrating than any gamma rays known, and the details of experimental results were very difficult to interpret on this basis. The next important contribution was reported in 1932 by Irène Joliot-Curie and Frédéric Joliot in Paris. They showed that if this unknown radiation fell on paraffin, or any other hydrogen-containing compound, it ejected protons of very high energy. This was not in itself inconsistent with the assumed gamma ray nature of the new radiation, but detailed quantitative analysis of the data became increasingly difficult to reconcile with such a hypothesis.

In 1932, James Chadwick performed a series of experiments at the University of Cambridge, showing that the gamma ray hypothesis was untenable. He suggested that the new radiation consisted of uncharged particles of approximately the mass of the proton, and he performed a series of experiments verifying his suggestion. These uncharged particles were called neutrons, apparently from the Latin root for neutral and the Greek ending -on (by imitation of electron and proton).

Gamma decay. Nuclear isomerism.

In gamma decay, depicted in Fig. 3-6, a nucleus changes from a higher energy state to a lower energy state through the emission of electromagnetic radiation (photons). The number of protons (and neutrons) in the nucleus does not change in this process, so the parent and daughter atoms are the same chemical element. In the gamma decay of a nucleus, the emitted photon and recoiling nucleus each have a well-defined energy after the decay. The characteristic energy is divided between only two particles.

Gamma decay, type of radioactivity in which some unstable atomic nuclei dissipate excess energy by a spontaneous electromagnetic process. In the most common form of gamma decay, known as gamma emission, gamma rays (photons, or packets of electromagnetic energy, of extremely short wavelength) are radiated. Gamma decay also includes two other electromagnetic processes, internal conversion and internal pair production. In internal conversion, excess energy in a nucleus is directly transferred to one of its own orbiting electrons, thereby ejecting the electron from the atom. In internal pair production, excess energy is directly converted within the electromagnetic field of a nucleus into an electron and a positron (positively charged electron) that are emitted together. Internal conversion always accompanies the predominant process of gamma emission to some extent. Some nuclei of a sample decay by gamma emission, others by internal conversion. Internal pair production requires that the excess energy of the unstable nucleus be at least equivalent to the combined masses of an electron and a positron (that is, in excess of 1,020,000 electron volts).

The unstable nuclei that undergo gamma decay are the products either of other types of radioactivity (alpha and beta decay) or of some other nuclear process, such as neutron capture in a nuclear reactor. These product nuclei have more than their normal energy, which they lose in discrete amounts as gamma-ray photons until they reach their lowest energy level, or ground state.

Typical half-lives for gamma emission are immeasurably short (from about 10-9 to 10−14 second). When the half-lives for gamma emission are measurable, the nucleus in the higher energy state before radiating a photon and the one in the lower energy state are called nuclear isomers. See also isomer.

The existence of excited states of atomic nuclei with unusually long lifetimes. If the lifetime of a specific excited state is unusually long, compared with the lifetimes of other excited states in the same nucleus, the state is said to be isomeric. The definition of the boundary between isomeric and normal decays is arbitrary, and the term is therefore used loosely. See Excited state, Parity (quantum mechanics), Spin (quantum mechanics)

The predominant decay mode of excited nuclear states is by γ-ray emission. The rate at which this process occurs is determined largely by the spins, parities, and excitation energies of the decaying state and of those to which it is decaying. In particular, the rate is extremely sensitive to the difference in the spins of initial and final states and to the difference in excitation energies. Both extremely large spin differences and extremely small energy differences can result in a slowing of the γ-ray emission by many orders of magnitude, resulting in some excited states having unusually long lifetimes and therefore being termed isomeric.

In addition to spin isomers, two other types of isomers have been identified. The first of these arises from the fact that some excited nuclear states represent a drastic change in shape of the nucleus from the shape of the ground state. In many cases this extremely deformed shape displays unusual stability, and states with this shape are therefore isomeric. A particularly important class of these shape isomers is observed in the decay of heavy nuclei by fission, and the study of such fission isomers has been the subject of intensive effort. See Nuclear fission

A more esoteric form of isomer has also been observed, the so-called pairing isomer which results from differences in the microscopic motions of the constituent nucleons in the nucleus. A state of this type has a quite different character from the ground state of the nucleus, and is therefore also termed isomeric.[19]

Nuclear reaction. Conservation laws of nuclear reactions. Mechanism of nuclear reactions.

In nuclear physics and nuclear chemistry, a nuclear reaction is semantically considered to be the process in which two nuclei, or else a nucleus of an atom and a subatomic particle (such as a proton, neutron, or high energy electron) from outside the atom, collide to produce one or more nuclides that are different from the nuclide(s) that began the process. Thus, a nuclear reaction must cause a transformation of at least one nuclide to another. If a nucleus interacts with another nucleus or particle and they then separate without changing the nature of any nuclide, the process is simply referred to as a type of nuclear scattering, rather than a nuclear reaction.

In principle, a reaction can involve more than two particles colliding, but because the probability of three or more nuclei to meet at the same time at the same place is much less than for two nuclei, such an event is exceptionally rare (see triple alpha process for an example very close to a three-body nuclear reaction). "Nuclear reaction" is a term implying an induced change in a nuclide, and thus it does not apply to any type of radioactive decay (which by definition is a spontaneous process).

Natural nuclear reactions occur in the interaction between cosmic rays and matter, and nuclear reactions can be employed artificially to obtain nuclear energy, at an

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[19] Onopriyenko O.V. Test your knowledge and skills of students in physics in high school : a book for teachers. M : Education, 1996 , c- 173

adjustable rate, on demand. Perhaps the most notable nuclear reactions are the nuclear chain reactions in fissionable materials that produces induced nuclear fission, and the various nuclear fusion reactions of light elements that power the energy production of the Sun and stars. Both of these types of reactions are employed in nuclear weapons.

Kinetic energy may be released during the course of a reaction (exothermic reaction) or kinetic energy may have to be supplied for the reaction to take place (endothermic reaction). This can be calculated by reference to a table of very accurate particle rest masses, as follows: according to the reference tables, the 6

3Li nucleus has a relative atomic mass of 6.015 atomic mass units

(abbreviated u), the deuterium has 2.014 u, and the helium-4 nucleus has 4.0026 u

Thus:

Total rest mass on left side = 6.015 + 2.014 = 8.029 u

Total rest mass on right side = 2 × 4.0026 = 8.0052 u

Missing rest mass = 8.029 – 8.0052 = 0.0238 atomic mass units.

In a nuclear reaction, the total (relativistic) energy is conserved. The "missing" rest mass must therefore reappear as kinetic energy released in the reaction; its source is the nuclear binding energy. Using Einstein's mass-energy equivalence formula $E = mc^2$, the amount of energy released can be determined. We first need the energy equivalent of one atomic mass unit:

$1 \text{ u } c^2 = (1.66054 \times 10-27 \text{ kg}) \times (2.99792 \times 108 \text{ m/s})^2$

$= 1.49242 \times 10-10 \text{ kg (m/s)}^2 = 1.49242 \times 10-10$ J (Joule)

$\times$ (1 MeV / $1.60218 \times 10-13$ J)

= 931.49 MeV,

so $1 \text{ u } c^2 = 931.49$ MeV.

Hence, the energy released is 0.0238 × 931 MeV = 22.4 MeV.

Expressed differently: the mass is reduced by 0.3%, corresponding to 0.3% of 90 PJ/kg is 300 TJ/kg.

This is a large amount of energy for a nuclear reaction; the amount is so high because the binding energy per nucleon of the helium-4 nucleus is unusually high, because the He-4 nucleus is "doubly magic". (The He-4 nucleus is unusually stable and tightly bound for the same reason that the helium atom is inert: each pair of protons and neutrons in He-4 occupies a filled 1s nuclear orbital in the same way that the pair of electrons in the helium atom occupy a filled 1s electron orbital). Consequently, alpha particles appear frequently on the right hand side of nuclear reactions.

The energy released in a nuclear reaction can appear mainly in one of three ways:

kinetic energy of the product particles

emission of very high energy photons, called gamma rays

some energy may remain in the nucleus, as a metastable energy level.

When the product nucleus is metastable, this is indicated by placing an asterisk ("*") next to its atomic number. This energy is eventually released through nuclear decay.

A small amount of energy may also emerge in the form of X-rays. Generally, the product nucleus has a different atomic number, and thus the configuration of its electron shells is wrong. As the electrons rearrange themselves and drop to lower energy levels, internal transition X-rays (X-rays with precisely defined emission lines) may be emitted.

Radiation dosimetry nuclei.

Radiation dosimetry is the measurement and calculation of the radiation dose received by matter and tissue resulting from the exposure to indirect and direct ionizing radiation. It is a scientific sub-specialty in the fields of health physics and medical physics that is focused on the calculation and analysis of internal and external dose. Internal dose is calculated from a variety of physiological techniques, whilst external dose is measured with a dosimeter or inferred from other radiation instruments.

Dosimetry is used extensively for radiation protection and is routinely applied to occupational radiation workers, where a radiation dose is expected, but regulatory levels must not be exceeded. It is also used where radiation is unexpected, such as in the aftermath of the Three Mile Island, Chernobyl or Fukishima radiological release incidents, where the public dose is measured and calculated from a variety of indicators such as ambient measurements of radiation and radioactive contamination.

Other significant areas are medical dosimetry, where the required treatment dose and any collateral dose is monitored, and in environmental dosimetry, such as radon monitoring in buildings.

In all cases the information is used to calculate any likely detrimental health effects.

There are several ways of measuring doses from ionizing radiation. People in occupational contact with radioactive substances or who may be exposed to radiation routinely carry personal dosimeters. These are specifically designed to record and indicate the dose received. Traditionally these were badges containing photographic film (film badge dosimeter), which would be chemically developed following exposure to indicate the total dose received. Film badges have now been largely replaced with other devices such as the TLD badge which uses Thermo luminescent dosimeter or optically stimulated luminescence (OSL) badges.

A number of electronic devices known as Electronic Personal Dosimeters (EPDs) have come into general use using semiconductor detection and programmable processor technology. These are worn as badges, but can give an indication of instantaneous dose rate and an audible and visual alarm if a dose rate or a total integrated dose is exceeded. A good deal of information can be made immediately available to the wearer of the recorded dose and current dose rate via a local display. They can be used as the main stand-alone dosimeter, or as a supplement to such as a TLD badge. These devices are particularly useful for real-time monitoring of dose where a high dose rate is expected which will time-limit the wearer's exposure.

The ICRP states that if a personal dosimeter is worn on a position on the body representative of its exposure, assuming whole-body exposure, the value of ambient dose equivalent H(10) is sufficient to provide an effective dose value suitable for radiological protection.

In certain circumstances dose can be inferred from readings taken by fixed instrumentation in an area in which the person concerned has been working. This would generally only be used if personal dosimetry had not been issued, or a personal dosimeter has been damaged or lost. Such calculations would take a pessimistic view of the likely received dose.

Medical dosimetry is the calculation of absorbed dose and optimization of dose delivery in radiation therapy. It is often performed by a professional medical dosimetrist with specialized training in the field. In order to plan the delivery of radiation therapy, the radiation produced by the sources is usually characterized with percentage depth dose curves and dose profiles measured by medical physicists. There are a number of different measures of radiation dose, including absorbed dose (D) measured in grays (Gy), Equivalent dose (H) measured in sieverts (Sv), Effective dose (E) (also measured in sieverts) and Kerma (K) measured in grays, along with dose area product (DAP) and dose length product (DLP). Each measure is often simply described as 'dose', which can lead to confusion. Non-SI units are still used, particularly in the USA, where dose is often reported in rads and dose equivalent in rems. By definition, 1 Gy = 100 rad and 1 Sv = 100 rem.

The fundamental measure of the biological effect of ionising radiation is the absorbed dose (D), which is defined as the mean energy imparted [by ionising radiation (dE) per unit mass (dm) of material (D = dE/dm) The SI unit of absorbed dose is the gray (Gy) defined as one joule per kilogram. Absorbed dose, as a point measurement, is suitable for describing localised (i.e. partial organ) exposures such as tumour dose in radiotherapy. It may be used to estimate stochastic risk provided the amount and type of tissue involved is stated. Localised diagnostic dose levels are typically in the 0-50 mGy range. At a dose of 1 milligray (mGy) of photon radiation, each cell nucleus is crossed by an average of 1 liberated electron track.[20]

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[20] Dukov V.M. Historical reviews of a physics course.M:Education, 2003, p- 45

Elementary particles. Classification of elementary particles. Quark model of elementary particles.

In particle physics, an elementary particle or fundamental particle is a particle whose substructure is unknown, thus it is unknown whether it is composed of other particles. Known elementary particles include the fundamental fermions (quarks, leptons, antiquarks, and antileptons), which generally are "matter particles" and "antimatter particles", as well as the fundamental bosons (gauge bosons and Higgs boson), which generally are "force particles" that mediate interactions among fermions. A particle containing two or more elementary particles is a composite particle.

Everyday matter is composed of atoms, once presumed to be matter's elementary particles—atom meaning "indivisible" in Greek—although the atom's existence remained controversial until about 1910, as some leading physicists regarded molecules as mathematical illusions, and matter as ultimately composed of energy. Soon, subatomic constituents of the atom were identified, although as the 1930s opened, only the electron, photon, and proton were known.By then, the recent advent of quantum mechanics was radically altering conception of particles, as a single particle could seemingly span a field as would a wave, a paradox still defying satisfactory explanation.

Via quantum theory, protons and neutrons were found to contain quarks—up quarks and down quarks—now considered elementary particles.And within a molecule, the electron's three degrees of freedom (charge, spin, orbital) can separate via wavefunction into three quasiparticles (holon, spinon, orbiton).Yet a free electron—which, not orbiting an atomic nucleus, lacks orbital motion—appears unsplittable and remains regarded as an elementary particle.

Around 1980, an elementary particle's status as indeed elementary—an ultimate constituent of substance—was mostly discarded for a more practical outlook, embodied in particle physics' Standard Model, science's most experimentally successful theory. Many elaborations upon and theories beyond the Standard Model, including the extremely popular string theory, double the number of elementary particles by hypothesizing that each known particle associates with a "shadow" partner far more massive, although all such super partners remain undiscovered. Meanwhile, an elementary boson mediating gravitation—the graviton—is generally presumed, but remains hypothetical.

According to the current models of big bang nucleon synthesis, the primordial composition of visible matter of the universe should be about 75% hydrogen and 25% helium-4 (in mass). Neutrons are made one up and two down quark, while protons are made of two up and one down quark. Since the other common elementary particles (such as electrons, neutrinos, or weak bosons) are so light or so rare when compared to atomic nuclei, we can neglect their mass contribution to the observable universe's total mass. Therefore, one can conclude that most of the visible mass of the universe is made of up quarks and down quarks.

In terms of number of particles, some estimates imply that nearly all the matter, excluding dark matter, occurs in neutrinos, and that roughly 1086 elementary particles of matter exist in the visible universe, mostly neutrinos. Other estimates imply that roughly 1097 elementary particles exist in the visible universe (not including dark matter), mostly photons, gravitons, and other mass less force carriers.

Isolated quarks and ant quarks have never been detected, a fact explained by confinement. Every quark carries one of three color charges of the strong interaction; ant quarks similarly carry antichlor. Color-charged particles interact via gluon exchange in the same way that charged particles interact via photon exchange. However, gluons are themselves color-charged, resulting in an amplification of the strong force as color-charged particles are separated. Unlike the electromagnetic force, which diminishes as charged particles separate, color-charged particles feel increasing force.

However, color-charged particles may combine to form color neutral composite particles called hadrons. A quark may pair up with an antiquark: the quark has a color and the antiquary has the corresponding antichlor. The color and anticolor cancel out, forming a color neutral meson. Alternatively, three quarks can exist together, one quark being "red", another "blue", another "green". These three colored quarks together form a color-neutral baryon. Symmetrically, three antiquarks with the colors "antired", "antiblue" and "antigreen" can form a color-neutral antibaryon.

Quarks also carry fractional electric charges, but, since they are confined within hadrons whose charges are all integral, fractional charges have never been isolated. Note that quarks have electric charges of either +2/3 or −1/3, whereas antiquarks have corresponding electric charges of either −2/3 or +1/3.

Evidence for the existence of quarks comes from deep inelastic scattering: firing electrons at nuclei to determine the distribution of charge within nucleons (which are baryons). If the charge is uniform, the electric field around the proton should be uniform and the electron should scatter elastically. Low-energy electrons do scatter in this way, but, above a particular energy, the protons deflect some electrons through large angles. The recoiling electron has much less energy and a jet of particles is emitted. This inelastic scattering suggests that the charge in the proton is not uniform but split among smaller charged particles: quarks.

Relativistic relations in a microworld.

The nuclear force (or nucleon–nucleon interaction or residual strong force) is the force between two or more nucleons. Its fundamental laws and constants are unknown unlike the Coulomb and Newton laws. It is responsible for binding protons and neutrons into atomic nuclei. The energy released by such binding causes the masses of nuclei to be less than the total mass of the protons and neutrons which form them; this is the energy used in nuclear power and nuclear weapons. The force is powerfully attractive between nucleons at distances of about 1 femtometer (fm) between their centers, but rapidly decreases to insignificance at distances beyond about 2.5 fm. At very short distances less than 0.7 fm, it becomes repulsive, and is responsible for the physical size of nuclei, since the nucleons can come no closer than the force allows.

The nuclear force is now understood as a residual effect of the even more powerful strong force, or strong interaction, which is the attractive force that binds particles called quarks together, to form the nucleons themselves. This more powerful force is mediated by particles called gluons, which are a type of gauge boson. Gluons hold quarks together with a force like that of electric charge, but of far greater power.

The concept of a nuclear force was first quantitatively constructed in 1934, shortly after the discovery of the neutron revealed that atomic nuclei were made of protons and neutrons, held together by an attractive force. The nuclear force at that time was conceived to be transmitted by particles called mesons, which were predicted in theory before being discovered in 1947. In the 1970s, further understanding revealed these mesons to be combinations of quarks and gluons, transmitted between nucleons that themselves were made of quarks and gluons. This new model allowed the strong forces that held nucleons together, to be felt in neighboring nucleons, as residual strong forces.

The nuclear forces arising between nucleons are now seen to be analogous to the forces in chemistry between neutral atoms or molecules called London forces. Such forces between atoms are much weaker than the attractive electrical forces that hold the atoms themselves together (i.e., that bind electrons to the nucleus), and their range between atoms is shorter, because they arise from small separation of charges inside the neutral atom. Similarly, even though nucleons are made of quarks in combinations which cancel most gluon forces (they are "color neutral"), some combinations of quarks and gluons nevertheless leak away from nucleons, in the form of short-range nuclear force fields that extend from one nucleon to another nucleon that is close by. These nuclear forces are very weak compared to direct gluon forces ("color forces" or strong forces) inside nucleons, and the nuclear forces extend only over a few nuclear diameters, falling exponentially with distance. Nevertheless, they are strong enough to bind neutrons and protons over short distances, and overcome the electrical repulsion between protons in the nucleus.

Like London forces, nuclear forces also stop being attractive and become repulsive, when nucleons are brought too close together.

The nuclear force has been at the heart of nuclear physics ever since the field was born in 1932 with the discovery of the neutron by James Chadwick. The traditional goal of nuclear physics is to understand the properties of atomic nuclei in terms of the 'bare' interaction between pairs of nucleons, or nucleon–nucleon forces (NN forces).

In 1934, Hideki Yukawa made the earliest attempt to explain the nature of the nuclear force. According to his theory, massive bosons (mesons) mediate the interaction between two nucleons. Although, in light of quantum chromodynamics (QCD), meson theory is no longer perceived as fundamental, the meson-exchange concept (where hadrons are treated as elementary particles) continues to represent the best working model for a quantitative NN potential.

Historically, it was a formidable task to describe the nuclear force phenomenologically, and the first semi-empirical quantitative models came in the mid-1950s. There has been substantial progress in experiment and theory related to the nuclear force. Most basic questions were settled in the 1960s and 1970s. In recent years, experimenters have concentrated on the subtleties of the nuclear force, such as its charge dependence, the precise value of the πNN coupling constant, improved phase shift analysis, high-precision NN data, high-precision NN potentials, NN scattering at intermediate and high energies, and attempts to derive the nuclear force from QCD.[21]

Structure of the atom. Rutherford's experiment and Rutherford's formula

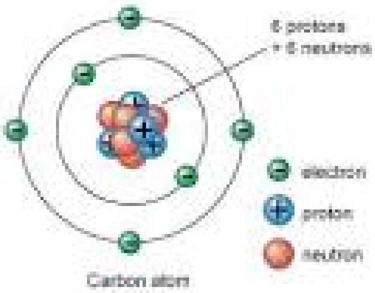
Atoms are composed of three type of particles: protons, neutrons, and electron. Protons and neutrons are responsible for most of the atomic mass e.g in a 150 person 149 lbs, 15 oz are protons and neutrons while only 1 oz. is electrons. The mass of an electron is very small (9.108 X 10-28 grams).

[21] Golin G.I. Filonovich SF Classics of physical science. M : High School, 1989 , with a 200 - glossary

Both the protons and neutrons reside in the nucleus. Protons have a postive (+) charge, neutrons have no charge --they are neutral. Electrons reside in orbitals around the nucleus. They have a negative charge (-).

It is the number of protons that determines the atomic number, e.g., H = 1. The number of protons in an element is constant (e.g., H=1, Ur=92) but neutron number may vary, so mass number (protons + neutrons) may vary.

The same element may contain varying numbers of neutrons; these forms of an element are called isotopes. The chemical properties of isotopes are the same, although the physical properties of some isotopes may be different. Some isotopes are radioactive-meaning they "radiate" energy as they decay to a more stable form, perhaps another element half-life: time required for half of the atoms of an element to decay into stable form. Another example is oxygen, with atomic number of 8 can have 8, 9, or 10 neutrons.



Rutherford’s formula for the effective scattering cross section of nonrelativistic charged point particles interacting according to Coulomb’s law. It was derived in 1911 by E. Rutherford.

In a center-of-mass system, that is, a system in which the total momentum of the colliding particles is equal to zero, Rutherford’s formula has the form

$$(*) \qquad \frac{d\sigma}{d\Omega} = \left(\frac{Z_1 Z_2 e^2}{2mv^2}\right)^2 \frac{1}{\sin^4(\theta/2)}$$

where dσ/dΩ is the scattering cross section into a unit solid angle, θ is the scattering angle, m = m1m2/(m1 + m2) is the reduced mass (m1 and m2 are the masses of the colliding particles), v is the relative velocity (the difference in the velocities of the particles), Z1e and Z2e are the electric charges of the particles, and e is the elementary electric charge. Rutherford’s formula is valid in both classical and quantum theory.

Formula (*) was used by Rutherford in interpreting experiments on the scattering of alpha particles at large angles (θ > 90°) on passage through thin metal foils. As a result of these experiments, Rutherford concluded that virtually the entire mass of the atom is concentrated in a small positively charged nucleus. This discovery formed the basis of modern conceptions of atomic structure.[22]

Bohr postulates. Experience Franck – Hertz.

As shown previously and later, Bohr had seen Balmer's equation which made "everything clear" for him.

He then was able to apply quantum theory to form his own model of the atom, which attempted to fix the limitations of Rutherford's model.

Bohr's postulates

1. Electrons in an atom exist in STATIONARY STATES.

Bohr stated that electrons orbit the nucleus WITHOUT emitting EM radiation.

Any permanent change in their motion must be accompanied by a complete transition from one stationary state to another.

Note that Bohr could NOT explain this.

2. Transmission between stationary states produces/absorbs EM Radiation.

When an electron moves between stationary states, it is accompanied by the emission or absorption of a photon.

This photon's energy is given by $\Delta E=hf$

Thus, EM radiation is produced by the movement of electrons between energy states which account for Planck's "atomic oscillators."

3. The angular momentum of a stationary electron is quantized

To explain, recall from Rutherford's model of the atom, in which the electrons orbited in circular orbits at any radii.

If this coincided with Bohr's 2nd postulate, it would mean that every element can emit a full spectrum as any transition would be possible.

As this is not the case, it would imply that electrons orbited at fixed radii.

Thus, this 3rd postulate allowed Bohr to explain the distinct spectra lines.

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[22] Braverman E.M. Class work in physics : the content and methodology of . M : High School, 1990

This can be represented mathematically by:

$$mvr = nh/2\pi$$

Note that you will never be asked to do equations with this, just remember it.

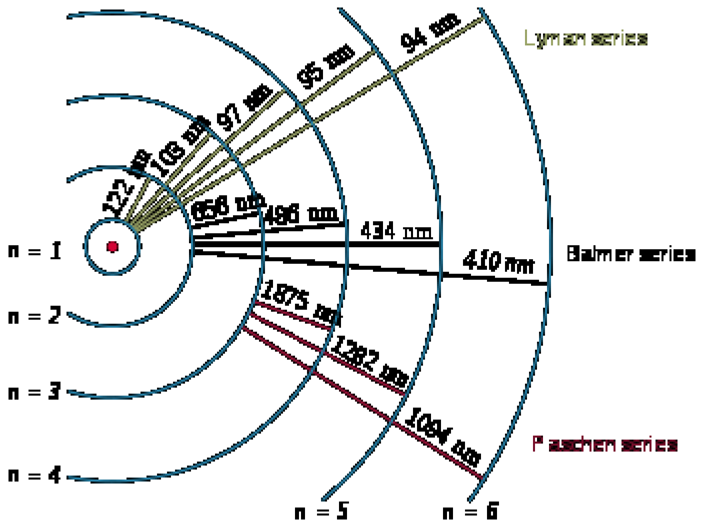
The purpose of this experiment is to reproduce the historic experiment carried out on mercury vapor by J. Franck and G. Hertz in 1914, for which they received a Nobel prize in 1924. The current experiment uses a neon-filled tube to demonstrate the existence of quantum levels.

In the original Franck-Hertz experiment shown schematically in Figure 1, mercury vapor in an otherwise evacuated tube was bombarded with electrons. To accelerate the electrons, the grid and plate potentials were kept at a variable higher potential than the filament, with the grid potential slightly higher than that of the plate. An ammeter measures the plate current. The small retarding potential between grid and plate prevents contributions to the plate current of electrons having negligible KE.

Spectral line of hydrogen atom.

The emission spectrum of atomic hydrogen is divided into a number of spectral series, with wavelengths given by the Rydberg formula. These observed spectral lines are due to electrons making a transition between two energy levels in the atom. The classification of the series by the Rydberg formula was important in the development of quantum mechanics. The spectral series are important in astronomy for detecting the presence of hydrogen and calculating red shifts.

A hydrogen atom consists of an electron orbiting its nucleus. The electromagnetic force between the electron and the nuclear proton leads to a set of quantum states for the electron, each with its own energy. These states were visualized by the Bohr model of the hydrogen atom as being distinct orbits around the nucleus. Each energy state, or orbit, is designated by an integer, n as shown in the figure. Spectral emission occurs when an electron transitions, or jumps, from a higher energy state to a lower energy state. To distinguish the two states, the lower energy state is commonly designated as n′, and the higher energy state is designated as n. The energy of an emitted photon corresponds to the energy difference between the two states. Because the energy of each state is fixed, the energy difference between them is fixed, and the transition will always produce a photon with the same energy.



The spectral lines are grouped into series according to n′. Lines are named sequentially starting from the longest wavelength/lowest frequency of the series, using Greek letters within each series. For example, the 2 → 1 line is called "Lyman-alpha" (Ly-α), while the 7 → 3 line is called "Paschen-delta" (Pa-δ). There are emission lines from hydrogen that fall outside of these series, such as the 21 cm line. These emission lines correspond to much rarer atomic events such as hyperfine transitions.The fine structure also results in single spectral lines appearing as two or more closely grouped thinner lines, due to relativistic corrections. The energy differences between levels in the Bohr model, and hence the wavelengths of emitted/absorbed photons, is given by the Rydberg formula:

$$\frac{1}{\lambda} = R\left(\frac{1}{(n')^2} - \frac{1}{n^2}\right) \qquad (R = 1.097373 \times 10^7 \text{ m}^{-1})$$

where n is the upper energy level, n′ is the lower energy level, and R is the Rydberg constant. Meaningful values are returned only when n is greater than n′ and the limit of one over infinity is taken to be zero.[23]

Bohr theory of the hydrogen atom. Crisis theory Bohr.

In 1913, the Danish physicist Niels Bohr (1885 - 1962) managed to explain the spectrum of atomic hydrogen by an extension of Rutherford's description of the atom. In that model, the negatively charged electrons revolve about the positively charged atomic nucleus because of the attractive electrostatic force according to Coulomb's law.

But the electron can be taken not only as a particle, but also as a de Broglie wave (wave of matter) which interferes with itself. The orbit is only stable, if it meets the condition for a standing wave: The circumference must be an integer multiple of the wavelength. The consequence is that only special values of radius and energy are allowed. The mathematical appendix explains how to calculate these values.

According to classical electrodynamics, a charge, which is subject to centripetal acceleration on a circular orbit, should continuously radiate electromagnetic waves. Thus, because of the loss of energy, the electron should spiral into the nucleus very soon. By contast, an electron in Bohr's model emits no energy, as long as its energy has one of the above-mentioned values. However, an electron which is not in the lowest energy level (n = 1), can make a spontaneous change to a lower state and thereby emit the energy difference in the form of a photon (particle of light). By calculating the wavelengths of the corresponding electromagnetic waves, one will get the same results as by measuring the lines of the hydrogen spectrum.

You must not take the idea of electrons, orbiting around the atomic nucleus, for reality. Bohr's model of the hydrogen atom was only an intermediate step on the

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[23] The Internet : http://nauka.vkpk.ru/katalog/sr2001/sr03_03/0012.htm # Elementary particles

way to a precise theory of the atomic structure, which was made possible by quantum mechanics and quantum electrodynamics.

This applet illustrates a hydrogen atom according to particle or wave model. You can choose a principal quantum number n. The right part of the graphics represents the energy levels of the atom. Right down at the bottom you can read off the orbital radius r and the total energy E.

If you try to vary the orbit's radius with pressed mouse button, this will generally lead to a non-stationary state. You can realize that by using the option "Wave model": The green wavy line which symbolizes the de Broglie wave will not be closed in most cases. Only if the circle's circumference is an integer multiple of the wavelength (blue), you will get a stationary state.

Failed attempts to understand the anomalous Zeeman effect contributed to the feeling of crisis that by 1924 characterized parts of the physics community. The solution proposed by W. Heisenberg's 'core model' only raised other problems. Another indication was the state of radiation theory and the uncertain relationship between wave theory and the light quantum, a problem that resulted in the controversial BKS (Bohr–Kramers–Slater) theory of 1924. In the wake of this theory, H. Kramers and Heisenberg constructed a formal theory of dispersion that did not rely on electron orbits but only on observable quantities, in agreement with the 'quantum mechanics' programme of M. Born. The development culminated with Heisenberg's paper of August 1925, which marks the end of the Bohr model and the beginning of quantum mechanics. The chapter reconsiders the crisis and the reasons for it, in particular the role of experimental anomalies.

Space and group velocity. Dualism.

The group velocity of a wave is the velocity with which the overall shape of the waves' amplitudes — known as the modulation or envelope of the wave — propagates through space.

For example, imagine what happens if a stone is thrown into the middle of a very still pond. When the stone hits the surface of the water, a circular pattern of waves appears. It soon turns into a circular ring of waves with a quiescent center. The ever expanding ring of waves is the wave group, within which one can discern individual wavelets of differing wavelengths traveling at different speeds. The longer waves travel faster than the group as a whole, but they die out as they approach the leading edge. The shorter waves travel more slowly and they die out as they emerge from the trailing boundary of the group.

Dualism (from the Latin word duo meaning "two")denotes a state of two parts. The term 'dualism' was originally coined to denote co-eternal binary opposition, a meaning that is preserved in metaphysical and philosophical duality discourse but has been diluted in other usages to indicate a system which contains two essential parts.

Moral dualism is the belief of the great complement or conflict between the benevolent and the malignant. It simply implies that there are two moral opposites at work, independent of any interpretation of what might be "moral" and independent of how these may be represented. The moral opposites might, for example exist in a world view which has one god, more than one god, or none. By contrast, ditheism or bitheism implies (at least) two gods. Bitheism implies harmony, ditheism implies rivalry and opposition, such as between good and evil, or bright and dark, or summer and winter. For example, a ditheistic system would be one in which one god is creative, the other is destructive.

Alternatively, in ontological dualism, the world is divided into two overarching categories. The opposition and combination of the universe's two basic principles of yin and yang is a large part of Chinese philosophy, and is an important feature of Taoism, both as a philosophy and as a religion (it is also discussed in Confucianism).

In theology, dualism can refer to the relationship between God and creation. The Christian dualism of God and creation exists in some traditions of Christianity, like Paulicianism, Catharism, and Gnosticism. The Paulicians, a Byzantine Christian sect, believed that the universe, created through evil, exists separately from a moral God. The Dvaita Vedanta school of Indian philosophy also espouses a dualism between God and the universe. The first and the more important reality is that of

Vishnu or Brahman. Vishnu is the supreme Self, God, the absolute truth of the universe, the independent reality. The second reality is that of dependent but equally real universe that exists with its own separate essence.

In philosophy of mind, dualism is a view about the relationship between mind and matter which claims that mind and matter are two ontologically separate categories. Mind-body dualism claims that neither the mind nor matter can be reduced to each other in any way. Western dualist philosophical traditions (as exemplified by Descartes) equate mind with the conscious self and theorize on consciousness on the basis of mind/body dualism. By contrast, some Eastern philosophies draw a metaphysical line between consciousness and matter — where matter includes both body and mind.

In philosophy of science, dualism often refers to the dichotomy between the "subject" (the observer) and the "object" (the observed). Another dualism, in Popperian philosophy of science refers to "hypothesis" and "refutation" (for example, experimental refutation). This notion also carried to Popper's political philosophy.

In physics, dualism also refers to media with properties that can be associated with the mechanics of two different phenomena. Because these two phenomena's mechanics are mutually exclusive, both are needed in order to describe the possible behaviors. An example of using to different physical models to describe one phenomenon is wave–particle duality.

Schrödinger equation. Quantum operators.

In quantum mechanics, the Schrödinger equation is a partial differential equation that describes how the quantum state of some physical system changes with time. It was formulated in late 1925, and published in 1926, by the Austrian physicist Erwin Schrödinger.

In classical mechanics, the equation of motion is Newton's second law, and equivalent formulations are the Euler–Lagrange equations and Hamilton's equations. All of these formulations are used to solve for the motion of a mechanical system and mathematically predict what the system will do at any time beyond the initial settings and configuration of the system.

In quantum mechanics, the analogue of Newton's law is Schrödinger's equation for a quantum system (usually atoms, molecules, and subatomic particles whether free, bound, or localized). It is not a simple algebraic equation, but (in general) a linear partial differential equation. The differential equation describes the wave function of the system, also called the quantum state or state vector.

The concept of a state vector is a fundamental postulate of quantum mechanics. Although often presented as a postulate, Schrödinger's equation can in fact be derived from symmetry principles.

In the standard interpretation of quantum mechanics, the wave function is the most complete description that can be given to a physical system. Solutions to Schrödinger's equation describe not only molecular, atomic, and subatomic systems, but also macroscopic systems, possibly even the whole universe.

Like Newton's second law (F = ma), the Schrödinger equation can be mathematically transformed into other formulations such as Werner Heisenberg's matrix mechanics, and Richard Feynman's path integral formulation. Also like Newton's second law, the Schrödinger equation describes time in a way that is inconvenient for relativistic theories, a problem that is not as severe in matrix mechanics and completely absent in the path integral formulation.

Time-dependent Schrödinger equation (general)

$$i\hbar\frac{\partial}{\partial t}\Psi = \hat{H}\Psi$$

Time-dependent Schrödinger equation (single non-relativistic particle)

$$i\hbar\frac{\partial}{\partial t}\Psi(\mathbf{r},t) = \left[\frac{-\hbar^2}{2m}\nabla^2 + V(\mathbf{r},t)\right]\Psi(\mathbf{r},t)$$

Time-independent Schrödinger equation (general)

$$E\Psi = \hat{H}\Psi$$

Time-independent Schrödinger equation (single non-relativistic particle)

$$E\Psi(\mathbf{r}) = \left[\frac{-\hbar^2}{2m}\nabla^2 + V(\mathbf{r})\right]\Psi(\mathbf{r})$$

Associated with each measurable parameter in a physical system is a quantum mechanical operator. Such operators arise because in quantum mechanics you are describing nature with waves (the wavefunction) rather than with discrete particles whose motion and dymamics can be described with the deterministic equations of Newtonian physics. Part of the development of quantum mechanics is the establishment of the operators associated with the parameters needed to describe the system. Some of those operators are listed below.

$f(x)$	Any function of position, such as x, or potential V(x)	$f(x)$
p_x	x component of momentum (y and z same form)	$\frac{\hbar}{i}\frac{\partial}{\partial x}$
E	Hamiltonian (time independent)	$\frac{p_{op}^2}{2m} + V(x)$
E	Hamiltonian (time dependent)	$i\hbar\frac{\partial}{\partial t}$
KE	Kinetic energy	$\frac{-\hbar^2}{2m}\frac{\partial^2}{\partial x^2}$
L_z	z component of angular momentum	$-i\hbar\frac{\partial}{\partial \phi}$

It is part of the basic structure of quantum mechanics that functions of position are unchanged in the Schrodinger equation, while momenta take the form of spatial derivatives. The Hamiltonian operator contains both time and space derivatives.

Motion of particles in a square potential well.

The Smoluchowski equation for the Brownian motion of two interacting particles through a square-well potential whose heights are infinitely large at the origin and finite at the other positions of u (>0) is solved exactly for the Laplace transform of the conditional density with respect to time t. The analytical expression for the distinct part of the dynamic structure factor at the initial time with the δ function has also been obtained exactly. Moreover, we have calculated the asymptotic behavior of the mean-square displacement expressed as an explicit function of t and found that it is a function of the height of the potential at u, which directly indicates a deviation from the Einstein relation.

The finite potential well (also known as the finite square well) is a concept from quantum mechanics. It is an extension of the infinite potential well, in which a particle is confined to a box, but one which has finite potential walls. Unlike the infinite potential well, there is a probability associated with the particle being found outside the box. The quantum mechanical interpretation is unlike the classical interpretation, where if the total energy of the particle is less than potential energy barrier of the walls it cannot be found outside the box. In the quantum interpretation, there is a non-zero probability of the particle being outside the box even when the energy of the particle is less than the potential energy barrier of the walls (cf quantum tunnelling).

Quantum theory of the hydrogen atom.

A hydrogen atom is an atom of the chemical element hydrogen. The electrically neutral atom contains a single positively charged proton and a single negatively charged electron bound to the nucleus by the Coulomb force. Atomic hydrogen constitutes about 75% of the elemental (baryonic) mass of the universe.[1]

In everyday life on Earth, isolated hydrogen atoms (usually called "atomic hydrogen" or, more precisely, "monatomic hydrogen") are extremely rare. Instead, hydrogen tends to combine with other atoms in compounds, or with itself to form ordinary (diatomic) hydrogen gas, H2. "Atomic hydrogen" and "hydrogen atom" in ordinary English use have overlapping, yet distinct, meanings. For example, a water molecule contains two hydrogen atoms, but does not contain atomic hydrogen (which would refer to isolated hydrogen atoms).

The hydrogen atom has special significance in quantum mechanics and quantum field theory as a simple two-body problem physical system which has yielded many simple analytical solutions in closed-form.

In 1913, Niels Bohr obtained the spectral frequencies of the hydrogen atom after making a number of simplifying assumptions. These assumptions, the cornerstones of the Bohr model, were not fully correct but did yield fairly correct energy answers (with a relative error in the ground state ionization energy of around α2/4 or around 10-5). Bohr's results for the frequencies and underlying energy values were duplicated by the solution to the Schrödinger equation in 1925–1926. The solution to the Schrödinger equation for hydrogen is analytical, giving a simple expressions for the hydrogen energy levels and thus the frequencies of the hydrogen spectral lines. The solution of the Schrödinger equation goes much further than the Bohr model, because it also yields the shape of the electron's wave function ("orbital") for the various possible quantum-mechanical states, thus explaining the anisotropic character of atomic bonds.

The Schrödinger equation also applies to more complicated atoms and molecules. When there is more than one electron or nucleus the solution is not analytical and either computer calculations are necessary or simplifying assumptions must be made.

The Schrödinger equation is not fully accurate. The next improvement was the Dirac equation (see below).

The solution of the Schrödinger equation (wave equations) for the hydrogen atom uses the fact that the Coulomb potential produced by the nucleus is isotropic (it is radially symmetric in space and only depends on the distance to the nucleus). Although the resulting energy eigenfunctions (the orbitals) are not necessarily isotropic themselves, their dependence on the angular coordinates follows completely generally from this isotropy of the underlying potential: the eigenstates of the Hamiltonian (that is, the energy eigenstates) can be chosen as simultaneous eigenstates of the angular momentum operator. This corresponds to the fact that angular momentum is conserved in the orbital motion of the electron around the nucleus. Therefore, the energy eigenstates may be classified by two angular momentum quantum numbers, ℓ and m (both are integers). The angular momentum quantum number ℓ = 0, 1, 2, ... determines the magnitude of the angular momentum. The magnetic quantum number $m = -\ell, ..., +\ell$ determines the projection of the angular momentum on the (arbitrarily chosen) z-axis.

In addition to mathematical expressions for total angular momentum and angular momentum projection of wavefunctions, an expression for the radial dependence of the wave functions must be found. It is only here that the details of the 1/r Coulomb potential enter (leading to Laguerre polynomials in r). This leads to a third quantum number, the principal quantum number n = 1, 2, 3, ... The principal quantum number in hydrogen is related to the atom's total energy.

Note that the maximum value of the angular momentum quantum number is limited by the principal quantum number: it can run only up to $n - 1$, i.e. $\ell = 0, 1, ..., n - 1$. Due to angular momentum conservation, states of the same ℓ but different m have the same energy (this holds for all problems with rotational symmetry). In addition, for the hydrogen atom, states of the same n but different ℓ are also degenerate (i.e. they have the same energy). However, this is a specific property of hydrogen and is no longer true for more complicated atoms which have a (effective) potential differing from the form 1/r (due to the presence of the inner electrons shielding the nucleus potential).

Taking into account the spin of the electron adds a last quantum number, the projection of the electron's spin angular momentum along the z-axis, which can take on two values. Therefore, any eigenstate of the electron in the hydrogen atom is described fully by four quantum numbers. According to the usual rules of quantum mechanics, the actual state of the electron may be any superposition of these states. This explains also why the choice of z-axis for the directional quantization of the angular momentum vector is immaterial: an orbital of given ℓ and m' obtained for another preferred axis z' can always be represented as a suitable superposition of the various states of different m (but same l) that have been obtained for z.

Angular and radial part of the Schrödinger equation.

The Schrödinger equation of the hydrogen atom in polar coordinates is:

$$-\frac{\hbar^2}{2\mu}\left[\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial\psi}{\partial r}\right)+\frac{1}{r^2\sin\theta}\frac{\partial}{\partial\theta}\left(\sin\theta\frac{\partial\psi}{\partial\theta}\right)+\frac{1}{r^2\sin^2\theta}\frac{\partial^2\psi}{\partial\varphi^2}\right]-\frac{Ze^2}{\pi\epsilon_0 r}\psi=E\psi$$

Both LHS and RHS contain a term linear in ψ, so combine:

$$\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial\psi}{\partial r}\right)+\frac{1}{r^2\sin\theta}\frac{\partial}{\partial\theta}\left(\sin\theta\frac{\partial\psi}{\partial\theta}\right)+\frac{1}{r^2\sin^2\theta}\frac{\partial^2\psi}{\partial\varphi^2}+\frac{2\mu}{\hbar^2}\left(E+\frac{Ze^2}{\pi\epsilon_0 r}\right)\psi=0$$

Using the Separation of Variables idea, we assume a product solution of a radial and an angular function:

$$\psi\,(r,\theta,\varphi)=R(r)\cdot Y\,(\theta,\varphi)$$

Since Y does not depend on r, we can move it in front of the radial derivative:

$$\frac{\partial\psi}{\partial r}=\frac{\partial}{\partial r}RY=Y\frac{\mathrm{d}R}{\mathrm{d}r}$$

and, similarly, R does not depend on the angular variables. Thus replace ψ and the differentials:

$$\frac{Y}{r^2}\frac{\mathrm{d}}{\mathrm{d}r}\left(r^2\frac{\mathrm{d}R}{\mathrm{d}r}\right)+\frac{R}{r^2\sin\theta}\frac{\partial}{\partial\theta}\left(\sin\theta\frac{\partial Y}{\partial\theta}\right)+\frac{R}{r^2\sin^2\theta}\frac{\partial^2 Y}{\partial\varphi^2}+\frac{2\mu}{\hbar^2}\left(E+\frac{Ze^2}{4\pi\epsilon_0 r}\right)RY=0$$

Multiply by r2 and divide by RY to separate the radial and angular terms:

$$\frac{1}{R}\frac{\mathrm{d}}{\mathrm{d}r}\left(r^2\frac{\mathrm{d}R}{\mathrm{d}r}\right)+\frac{1}{Y\sin\theta}\frac{\partial}{\partial\theta}\left(\sin\theta\frac{\partial Y}{\partial\theta}\right)+\frac{1}{Y\sin^2\theta}\frac{\partial^2 Y}{\partial\varphi^2}+\frac{2\mu r^2}{\hbar^2}\left(E+\frac{Ze^2}{4\pi\epsilon_0 r}\right)=0$$

The first and fourth terms depend on r only, the middle terms depend on the angles only. They can only balance each other for all points in space if the radial and angular terms are the same constant but with opposite sign.

Therefore, we can separate into a radial equation:

$$\frac{\mathrm{d}}{\mathrm{d}r}\left(r^2\frac{\mathrm{d}R}{\mathrm{d}r}\right)+\frac{2\mu r^2}{\hbar^2}\left(E+\frac{Ze^2}{4\pi\epsilon_0 r}\right)R-AR=0$$

...and an angular equation: $\frac{1}{\sin\theta}\frac{\partial}{\partial\theta}\left(\sin\theta\frac{\partial Y}{\partial\theta}\right)+\frac{1}{\sin^2\theta}\frac{\partial^2 Y}{\partial\varphi^2}+AY=0$

where A is the separation constant.

Electron Orbit Magnetic Moment. Electron spin.

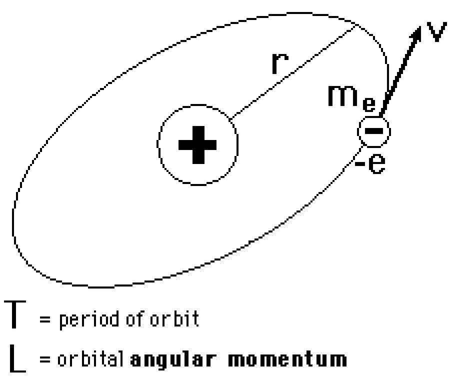
From the classical expression for magnetic moment, m = IA, an expression for the magnetic moment from an electron in a circular orbit around a nucleus can be deduced. It is proportional to the angular momentum of the electron. The effective current is

$$I = \frac{-e}{T} = \frac{ev}{2\pi r}$$

which can be rewritten as $$I = \frac{-e m_e v r}{2\pi m_e r^2}$$

so that the magnetic moment is $$\mu = IA = \frac{-e}{2m_e} L$$

An electron spin s = 1/2 is an intrinsic property of electrons. Electrons have intrinsic angular momentum characterized by quantum number 1/2. In the pattern of other quantized angular momenta, this gives total angular momentum



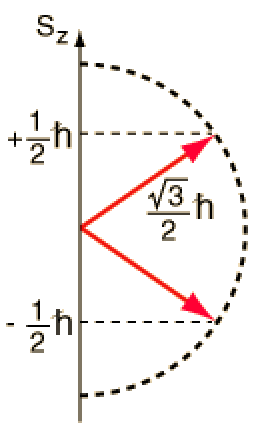
$$S = \sqrt{\frac{1}{2}\left(\frac{1}{2}+1\right)}\hbar = \frac{\sqrt{3}}{2}\hbar$$

The resulting fine structure which is observed corresponds to two possibilities for the z-component of the angular momentum

$$S_z = \pm\frac{1}{2}\hbar$$

This causes an energy splitting because of the magnetic moment of the electron

$$\mu_S = -\frac{e}{2m} gS$$



Spin "up" and "down" allows two electrons for each set of spatial quantum numbers.

Two types of experimental evidence which arose in the 1920s suggested an additional property of the electron. One was the closely spaced splitting of the hydrogen spectral lines, called fine structure. The other was the Stern-Gerlach experiment which showed in 1922 that a beam of silver atoms directed through an inhomogeneous magnetic field would be forced into two beams. Both of these experimental situations were consistent with the possession of an intrinsic angular momentum and a magnetic moment by individual electrons. Classically this could occur if the electron were a spinning ball of charge, and this property was called electron spin.

Quantization of angular momentum had already arisen for orbital angular momentum, and if this electron spin behaved the same way, an angular momentum quantum number s = 1/2 was required to give just two states.

Mechanical and magnetic moments of atoms.

Single magnetic atoms, and assemblies of such atoms, on non-magnetic surfaces have recently attracted attention owing to their potential use in high-density magnetic data storage and as a platform for quantum computing1, 2, 3, 4, 5, 6, 7, 8. A fundamental problem resulting from their quantum mechanical nature is that the localized magnetic moments of these atoms are easily destabilized by interactions with electrons, nuclear spins and lattice vibrations of the substrate3, 4, 5. Even when large magnetic fields are applied to stabilize the magnetic moment, the observed lifetimes remain rather short5, 6 (less than a microsecond). Several routes for stabilizing the magnetic moment against fluctuations have been suggested, such as using thin insulating layers between the magnetic atom and the substrate to suppress the interactions with the substrate's conduction electrons2, 3, 5, or coupling several magnetic moments together to reduce their quantum mechanical fluctuations7, 8. Here we show that the magnetic moments of single holmium atoms on a highly conductive metallic substrate can reach lifetimes of the order of minutes. The necessary decoupling from the thermal bath of electrons, nuclear spins and lattice vibrations is achieved by a remarkable combination of several symmetries intrinsic to the system: time reversal symmetry, the internal symmetries of the total angular momentum and the point symmetry of the local environment of the magnetic atom.[24]

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[24] The Internet : http://vikipedia.ru/katalog/sr2000/sr07_04/0122.htm # Mechanical and magnetic moments of atoms

The Pauli principle.

The Pauli exclusion principle is the quantum mechanical principle that no two identical fermions (particles with half-integer spin) may occupy the same quantum state simultaneously. In the case of electrons, it can be stated as follows, It is impossible for two electrons of a poly-electron atom to have the same values of the four quantum numbers (n, ℓ, m_ℓ and m_s). For two electrons residing in the same orbital, n, ℓ, and m_ℓ are the same, so m_s must be different and the electrons have opposite spins. This principle was formulated by Austrian physicist Wolfgang Pauli in 1925.

A more rigorous statement is that the total wave function for two identical fermions is anti-symmetric with respect to exchange of the particles. This means that the wave function changes its sign if the space and spin co-ordinates of any two particles are interchanged.

Integer spin particles, bosons, are not subject to the Pauli exclusion principle: any number of identical bosons can occupy the same quantum state, as with, for instance, photons produced by a laser and Bose–Einstein condensate.

The Pauli exclusion principle governs the behavior of all fermions (particles with "half-integer spin"), while bosons (particles with "integer spin") are not subject to it. Fermions include elementary particles such as quarks (the constituent particles of protons and neutrons), electrons and neutrinos. In addition, protons and neutrons (subatomic particles composed from three quarks) and some atoms are fermions, and are therefore subject to the Pauli exclusion principle as well. Atoms can have different overall "spin", which determines whether they are fermions or bosons — for example helium-3 has spin 1/2 and is therefore a fermion, in contrast to helium-4 which has spin 0 and is a boson. As such, the Pauli exclusion principle underpins many properties of everyday matter, from its large-scale stability, to the chemical behavior of atoms.

"Half-integer spin" means that the intrinsic angular momentum value of fermions is $\hbar = h/2\pi$ (reduced Planck's constant) times a half-integer (1/2, 3/2, 5/2, etc.).

In the theory of quantum mechanics fermions are described by antisymmetric states. In contrast, particles with integer spin (called bosons) have symmetric wave functions; unlike fermions they may share the same quantum states. Bosons include the photon, the Cooper pairs which are responsible for superconductivity, and the W and Z bosons. (Fermions take their name from the Fermi–Dirac statistical distribution that they obey, and bosons from their Bose–Einstein distribution).

Analyzing the study of elementary particle physics section in continuing education to the following conclusions:

In universities in the study areas of particle physics must also be widely used computer technology showing various processes involving elementary particles, as well as included in the training process of the latest achievements in this field. For example: "Large Hadrons Collider", "dark matter", "dark energy", etc. Extensive use of computer technology ensures clarity of printed educational process and help to better master the subject.

4. Continuity in the study of the topic "Elementary Particles" in continuing education

According to the calendar and thematic plan on physics for grades 6-9 Secondary school study of particle physics is not provided in only 3 quarters assigned to Class 9 for 1 hour , only 4 hours for the consideration of those “Atom and structure of the Atom”, “Protons and neutrons”, “Nuclear energy and its use”, “The work conducted in the field of nuclear physics in Uzbekistan”.

In "The curriculum and industry standards of academic lyceums direction of exact sciences " Center of secondary special and professional education of the Ministry of Higher and Secondary Special Education of the Republic of Uzbekistan physics being the main subject of training , study of 608 hours. Here we consider the notions of elementary particles as " elementary particles . Cosmic rays . Unified physical picture of the world ", which is given 20 hours. It provides an explanation of the following concepts : "garden" of elementary particles , the discovery of the positron , the antiparticle , the quantities characterizing the elementary particles , conservation laws in elementary particle physics , the quark model of elementary particles, types of physical interactions in nature :

Nuclear, electromagnetic , weak, and gravitational interactions , the concept of unified theory of physical interactions in nature , the concept of cosmic rays , their chemical composition, soft and hard components of cosmic ray spectra of cosmic rays , cosmic rays passing through the atmosphere , nuclear and electromagnetic cascades of Uzbek scientists to study cosmic rays , a unified physical picture of the world . Based on the foregoing, we consider the scientific and methodological problems of teaching elementary particle physics in secondary special and professional education . This discipline has specific difficulties not only from a scientific point of view but also in terms of teaching. Unlike other sections , the rate of particle physics has its own characteristics . In particular, as a result of this course is formed by way of thinking peculiar to the world of elementary particles , contributing to the development of particular microcosm , on the other hand, has a significant impact on the attitudes of students. Naturally, in order to achieve the learning objectives of the course , based on the principle of continuity in training .

The program does not provide for demonstration experiments on the subject, carried only two labs:

1) study hard and soft components of cosmic rays;

2) the study of cosmic rays

In "The curriculum in physics for academic lyceums and professional colleges," published in 2004 by the Center of secondary special and professional education at the Ministry of Higher secondary special education, physics is Osnavnoy preparatory discipline, and have 160 hours.

Conclusions on the second chapter.

The second chapter examines the state of the teaching section of elementary particle physics in schools, professional colleges and academic lyceums natural, accurate and humanitarian areas. And rasmotreli principle of continuity in the study of elementary particle physics section in continuing education. In secondary schools, students become familiar only initial ideas about elementary particles. And in professional colleges and academic lyceums they continue to study this section using electronic textbooks and modern teaching technologies. But the students have difficulty relating to the submission of the information received in the study of this branch of physics. Consequently, the teaching of this section must use the methods of new educational technologies and build a lecture based on interdisciplinary communication.

Chapter III. Pedagogical experiment and its results

Pedagogical experiment - it originally designed and implemented learning physics, which involves a teacher observation in controlled and accountable under conditions of tasks .

Pedagogical experiments is one of the most difficult and fundamental methods of pedagogical research . Pedagogical experiment closely associated with teacher observations , but it is not limited thereto. Pedagogical experiment as a specific process in the teaching of physics , enables teacher observations under these conditions . There are three main characteristics that define the content of the pedagogical experiment , which differs radically from the pedagogical experiment pedagogical research :

1) the introduction of necessary changes in the learning process according to hypothesize and purpose of the study ;

2) the creation of conditions that reflect the relationship between different aspects of the learning process and ensure their in-depth study ;

3) records of the results of the educational process and the changes introduced into it .

The purpose of the pedagogical experiment is to determine the effectiveness of the means and methods, the volume of educational material in the learning process .

The most common form of pedagogical experiment is to compare the learning outcomes in the control and experimental classes . In this case, one of the classes selected for the experiment is taught recommendable procedure .

Pedagogical supervision occurs in vivo , and in pedagogical experiment is an active impact on the learning process by creating special conditions for test purpose of the experiment . Pedagogical experiment duration from a few weeks to several years. One form is the pedagogical experiment comparing study in experimental and control groups. In the experimental group were administered the experimental factor , which is absent in control groups.

taken into account :

- Quantitative factor ;
- The credibility of the haul;

Test performance (specially selected tasks to test students' knowledge , which has a short simple answer); questionnaires ; theoretical analysis (structural - logical analysis of teaching material and student's knowledge , statistical evaluation of individual elements of the teaching of physics) . Systematic approach (the process of learning physics represent , as a complex multi-level system , which operates under the influence of various factors . construct a generalized model, which reflects all the factors of the educational process and communication) .

Physics course is a mandatory course in average paid to cutting

Why ? Physics develops thinking , is the science of the world around us , physics element of general culture ;

It is the theoretical foundation of modern technology helps learn about the world, is an element of the universal culture. Physics uses mathematics as a tool. Due to the physics of developing (now) mathematics. Physics used in geology, biology, chemistry . The differentiation and integration of sciences.

From the new sciences of physics bud

The results of teaching experiments

Tashkent state pedagogical University named after Nizami

Opening lessons held for students in grades 3-course in Tashkent state pedagogical University named after Nizami. Students in found 9-13correct answers.

First result.

Group	**301**	**302**	**303**
5 mark	6	3	5
4 mark	12	11	11
3 mark	3	7	4

Second result (use method "Know, I will know, I don't know")

Guruh	**301**	**302**	**303**
5 baho	8	5	7
4 baho	12	11	11
3 baho	3	7	5

The result was to increase students' knowledge 4-7 %.

Tests for students

1. According to modern concepts antiparticle is ...

A. Only the electron

B. each particle

B. Only the proton , only the neutron

D. do not exist

2. According to modern concepts fundamental particles (ie particles do not consist of other particles) are...

A. protons

B. leptons

V. Quarks

G. neutrons

3. Which particles are leptons?

A. electrons

B. protons

B. Neutrons

G. neutrinos

4. How has the unusual property of quarks?

A lack of charge

B. presence of a charge

B. the presence of a fractional charge

G. lack of mass

5. What is the difference and what is common among particles and antiparticles ?

A mass is different, the same charges

B. and the masses and charges of the same

B. the same mass, different charges

G. and masses and different charges

6. Which of the particles is not open?

A positron

B. neutrinos

V. Graviton

G. photon

7. From what quark is a neutron?

A. Two quark with a charge of +2 e / 3 and one quark with a charge - 1e / 3

B. One quark with a charge of +2 e / 3 and one quark with a charge - 1e / 3

B. One quark with a charge of +2 e / 3 and two quarks with charge - 1e / 3

G. Two quarks with charge +2 e / 3 and two quarks with charge - 1e / 3

8. From what proton consists of quarks?

A. Two quark with a charge of +2 e / 3 and one quark with a charge - 1e / 3

B. One quark with a charge of +2 e / 3 and one quark with a charge - 1e / 3

B. One quark with a charge of +2 e / 3 and two quarks with charge - 1e / 3

G. Two quarks with charge +2 e / 3 and two quarks with charge - 1e / 3

9. At the collision of particle and antiparticle happens...

A. antistognatsiya

B. annistollyatsiya

V. Antropolyatsiya

G. annihilation

10. Which year was opened and named as the antiparticle of an electron ?

A. In 1932, anti-electron

B. in 1930, positron

B. In 1932, a positron

G. In 1930, anti-electron

11. The electron and positron in a collision in turn ...

A proton

B. neutron

B. Neutrinos

G. two photons

12. Which particles are Adrona?

A proton

B. Neutron

B. Neutrinos

G. electron

13. Which of the following particles is not open?

A. Positron

B. graviton

B. Neutrinos

G. Photon

14. What energy is released during electron and positron annihilation?

A. $m_e \cdot c$ Б. $\frac{m_e c^2}{2}$ B. $2 \cdot m_e \cdot c$ Г. $m_e c^2$.

15. Proton comprises:

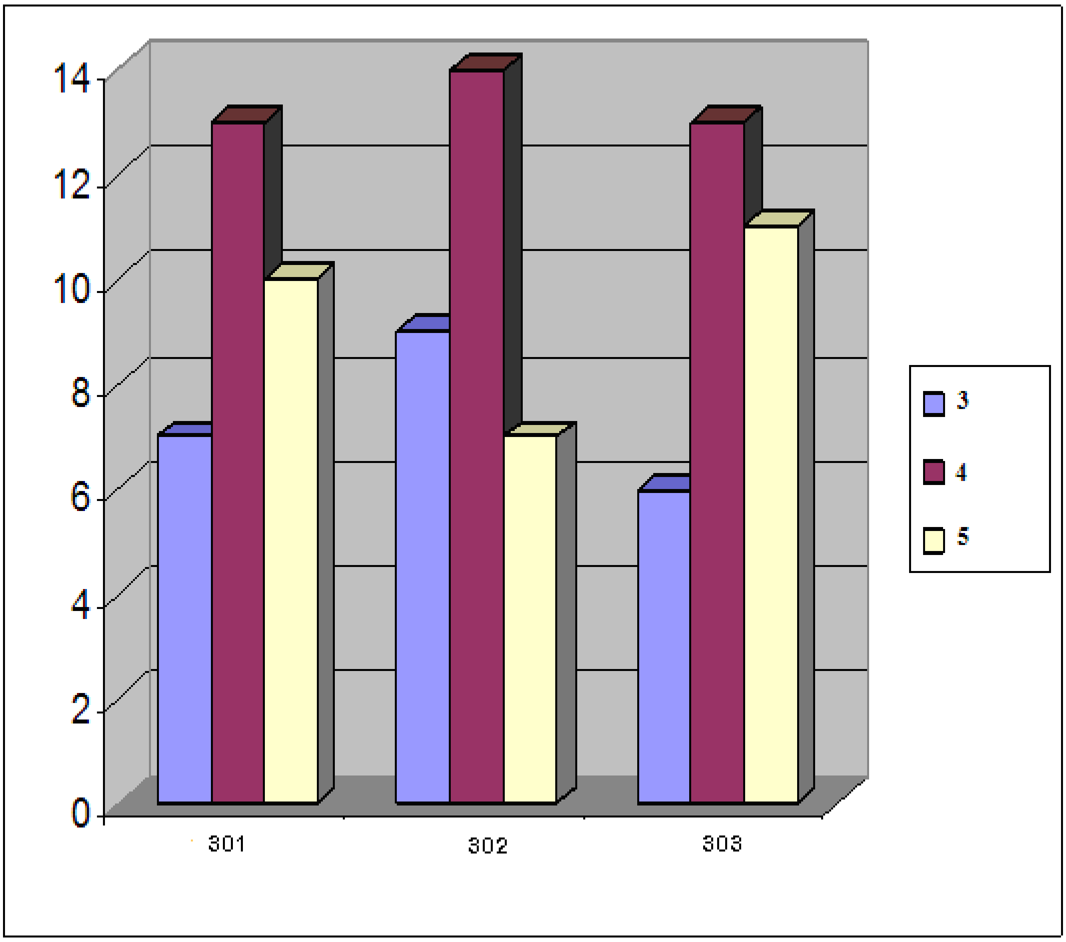
A neutron, a positron and a neutrino

B. Mesons

B. Quark

G. The proton has no component parts.

Diagram



Conclusions of the third chapter.

The third chapter covers conduct pedagogical experiments and analyzing their results. Opening lessons held for students in grades 3-course in Tashkent state pedagogical University named after Nizami. Students are found 9-13correct answers. Students were given 15 questions testing.

Conclusions:

A study of state education section of elementary particle physics in secondary schools , academic lyceums and professional colleges , problem teaching methods in this section, as well as on the basis of the results of the final qualifying work can make the following conclusion :

• studied the physiological factors of students being one of the factors the implementation of the principle of continuity.

• studied physics interdisciplinary communication with other items , to ensure implementation of the principle of continuity in the study of elementary particle physics section in continuing education .

• The state of teaching an elementary particle physics in secondary schools, academic lyceums (sending humanitarian, natural and exact sciences) and vocational colleges.

• The method of teaching an elementary particle physics in secondary schools, academic lyceums (direction humanities, natural and exact sciences) and vocational colleges.

• A continuity in the study of elementary particle physics section in continuing education .

• Conducted educational experiment to determine the students' knowledge , given the implementation of the principle of continuity in the study of elementary particle physics section .

• analyze the results of the pedagogical experiment , which are built on the basis of the corresponding diagrams .

• Based on the analysis results of the pedagogical experiment corresponding conclusions

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