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PROPERTIES OF FUNDAMENTAL CONSTANTS AND THEIR ROLE IN THE PHYSICAL PICTURE OF THE WORLD

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Abstract:
The article analyzes the methodological significance of physical constants in the formation of a physical picture of the World. It is proved that the fundamental physical constants are the constants included in the equations describing the basic laws of nature and properties of matter. Physics shows the importance of constants in the physical knowledge of the World.

Keywords: physical constants, physical picture of the World, versatility, reflection of the properties of elementary particles, entering into mathematical expressions for fundamental physical laws in the form of proportionality coefficients, performing the function of natural scales of physical quantities, the commonality of the magnitude status for different physical theories and its definition of the boundary conditions for the application of these theories, establishing the identity of physical concepts in different, physical theories.

Introduction

The current level of scientific development is characterized by the use of fundamental constants, the status of which is implied by itself. The concepts of fundamental constants in the ideas of major scientists often do not coincide, but fundamental physical constants are characterized by common properties:

- versatility;
- reflection of the properties of elementary particles;
- entering into mathematical expressions for fundamental physical laws in the form of proportionality coefficients;
- performing the function of natural scales of physical quantities;
- the commonality of the magnitude status for different physical theories and its definition of the boundary conditions for the application of these theories;
- establishing the identity of physical concepts in different physical theories;
- they are the basis for the creation of a unified physical theory and the evolution of physical knowledge in the future.

This property is most often used in the sense of general significance, general applicability in use. This is reflected in the use of the term "universal constant" for some constants that were included in the mathematical expression for classical universal laws: universal gravitation, thermal radiation, thermal expansion of gases, etc. The discovery of quantum and relativistic laws limited the scope of application of classical laws and reduced the level of their universality for theoretical and practical use. The property of universality has become more characteristic of some physical constants, which define the boundaries of the application of classical theoretical laws. The property of universality of physical constants for the universe is important for various fields of science: theoretical physics, theoretical metrology, astrophysics, philosophy, etc. The importance of this property for metrology (quantum metrology) was emphasized by J.K. Maxwell, M. Planck, J. Stony and other outstanding scientists who sought to build natural systems of units of physical quantities. Maxwell called such physical constants universal in his natural system of units of physical quantities.

Fundamental physical constants reflect various properties of elementary particles: mass, velocity, quantum characteristics, magnetic moments, etc. For example, the charges of elementary particles are expressed in units of elementary charge e. The velocities of the particles are limited by the limiting velocity c, which only photons have — particles that do not have mass. The spins of elementary particles are multiples of Planck's constant *h/2*. It should be noted here that the gravitational constant G differs from other physical constants. So far, there is no scientific evidence indicating any role for it in determining the properties of elementary particles. Attempts have been made to prove the stability of the electron by gravity. However, the comparison of the forces of gravity and electromagnetic interaction for the same particle makes the mechanism of electron stability based on the forces of gravity unlikely. Gravity and other interactions known in physics are considered in isolation from each other. At the same time, based on the principles of the unity of the world and the unity of physical interactions, there is a prospect of their unification.

Physical constants are included in mathematical expressions for physical laws in the form of proportionality coefficients. For example, the formula for the law of universal gravitation includes the gravitational constant G as a proportionality coefficient, the Schrodinger equation and other equations of quantum mechanics include Planck's constant h, and all equations of relativistic theories include the speed of light C.

In the equations of modern physics, the coefficients of proportionality as constant physical quantities have a dimension and a specific value, depending on the choice of a system of units of physical quantities. Some scientists consider these properties to be the definition of a fundamental physical constant. Volume 5 of the Physical Encyclopedia, published in 1998, states: "Fundamental physical constants are constants included in equations describing the fundamental laws of nature and properties of matter." At the same time, it is known that it is possible to exclude fundamental physical constants from expressions for physical laws by choosing an appropriate system of units of physical quantities. It represents a natural system of units and contains dimensionless definitions of velocity, angular momentum, charge, mass, etc. This is how D. Hartley's system of units of physical quantities is arranged. A. Poincare also spoke about the possibility of eliminating multipliers in equations reflecting physical patterns. It should be noted that the fundamental physical constants do not disappear at all, but pass into the definition of a physical quantity, just as the introduction of dimensionless mathematical expressions leads to the inclusion of dimensional coefficients of proportionality in the definitions of mathematical quantities themselves. This allows you to use the same mathematical equations to solve problems in various fields of science and technology.

Fundamentally, fundamental physical constants are the natural scales of the physical quantities that are associated with them. The speed of light in a vacuum is a natural unit of speed, which is used to create a standard unit of physical length — a meter. The elementary charge e is a natural unit of electric charge, since any electric charge is an integer multiple of the elementary charge. Planck's constant h is the natural unit for the angular momentum and spin of elementary particles. The Boltzmann constant is the natural unit for entropy and heat capacity. It should be noted that there are physical constants that are not measures (scales) of any physical quantities. For example, the gravitational constant G, considered as a fundamental physical constant, is not a natural measure of any magnitude.

At the same time, quantum mechanics quantities can be used as measures in astrophysics, which are derivatives of three physical constants: the speed of light c, Planck's constant B and the gravitational constant G. The property of fundamental physical constants to act as measures (scales) was emphasized by the outstanding physicist V. Heisenberg. He noted that physical constants can constitute "characteristic physical quantities" to which all other quantities in nature can be reduced (or replaced). This explains the appearance of Hartley's natural system of units of physical quantities in atomic physics based on Planck's constant ft, elementary charge e and electron mass, the relativistic ch-system in quantum electrodynamics; Maxwell's system based on the speed of light c and the gravitational constant G in the relativistic theory of gravitation.

It should be noted that it is more convenient to use other natural measures common in more limited fields of science and technology to solve applied problems in mechanics. For example, the Mach number is more convenient for measuring the speed of an object in aerodynamics than the speed of light; the dynamic viscosity of liquids as a physical quantity is more convenient in hydrodynamics than complexes containing the speed of light c and the gravitational constant G.

The creation of various theories and their results have led to the establishment of the fact that individual physical constants are common values for them. For example, the speed of light is included in mathematical expressions in such relativistic theories as mechanics, electrodynamics, thermodynamics, etc. Planck's constant fr(h) is present in all descriptions of quantum phenomena and effects. The theories of gravity use the speed of light with. The exception is the elementary charge E. There are currently no theories like classical mechanics or special relativity with which the elementary charge e would be associated. Nevertheless, the elementary charge e is included in the equations of classical electrodynamics along with the physical constants c and Y. The physical constants included in the expressions of different theories have been found to limit the scope of these theories. The speed of light limits the scope of classical mechanics, Planck's constant also introduces limitations in the application of equations of classical mechanics, the curvature of the surface limits the properties of Euclidean and non-Euclidean geometries, etc.

Fundamental physical constants establish the identity of physical concepts in different theories. This was most clearly revealed when comparing the results of applying theoretical propositions for wave and corpuscular theories in mechanics and accepting the admissibility of using the conclusions of both theories. In these theories, the speed of light in a vacuum acts as a proportionality coefficient. The wave velocity co and the velocity of the material object v are related by the de Broglie equation. Planck's constant, as a proportionality coefficient, establishes the correspondence between energy and frequency, momentum and wave vector in the corpuscular and wave theories.

The gravitational constant G is considered by some physicists as a coefficient of proportionality between two different physical quantities: gravitational and inert masses. Currently, there is no reason to distinguish between these two physical quantities and they are assumed to be identical to each other. The gravitational constant appears only in the formula for the law of universal gravitation.

The justification and introduction of fundamental physical constants to a certain extent reflects the development of physical theories. Initially, there were no physical constants in classical physics that were of fundamental importance. After the emergence and development of relativistic mechanics and quantum mechanics, fundamental physical constants appeared: the speed of light c and Planck's constant Y. Newton's theory of gravity is related to the fundamental physical constant G. At the same time, the role of the gravitational constant G in this theory differs significantly from the role of the physical constants c in special relativity and h in quantum mechanics. The gravitational constant is not a scale (measure) of any physical quantity. Newton's theory of gravity can be formally constructed without a gravitational constant. In fact, for several decades after its establishment, the law of gravity was considered without this constant. The creation and development of relativity theories led to the emergence of the principle of correspondence between physical quantities in different theories. It turned out that the new theories do not reject the previous ones. Moreover, the previous theories retain their significance, as they allow us to understand that they are the limiting states of new generalizing theories. Fundamental physical constants introduce limitations in the field of application of classical theories.

After the creation of the special theory of relativity, it became necessary to create a relativistic theory of gravitation, the limiting states of which were to be Newton's theory of gravitation and the special theory of relativity. After quantum mechanics, it became necessary to create a relativistic quantum theory based on two fundamental physical constants: the speed of light c and Planck's constant B, which was created. Further development of physics is associated with the creation of more general theories using a larger number of fundamental constants. The unified physical theory is presented by its supporters as a theory based on three fundamental constants: the speed of light c, Planck's constant h and the gravitational constant G. It is assumed that the general theory of relativity and relativistic quantum theory will represent the limiting states of the new general theory.

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