Journal of High Energy Physics, Gravitation and Cosmology, 2023, 9, 1208-1216
https://www.scirp.org/journal/jhepgc
ISSN Online: 2380-4335
ISSN Print: 2380-4327

The Principle of Differentiation into Physical and Mathematical Theories

Anatoly Parfyonov

Laboratory of X-Ray Structural Analysis, Ulyanovsk State Technical University, Ulyanovsk, Russia
Email: avparfo@gmail.com, parfyonov.anatoly.v@yandex.ru

How to cite this paper: Parfyonov, A. (2023) The Principle of Differentiation into Physical and Mathematical Theories. *Journal of High Energy Physics, Gravitation and Cosmology*, **9**, 1208-1216.
https://doi.org/10.4236/jhepgc.2023.94085

Received: August 23, 2023
Accepted: October 23, 2023
Published: October 26, 2023

Abstract

The article formulates the main principle of physics, which underlies this science. This principle has been called by the author of this article the Principle of differentiation into physical and mathematical theories. The article gives examples of the application of this principle in quantum mechanics and cosmology. A more detailed proof of the principle of equivalence of the electromagnetic field and the field of strong interaction to a free material particle is given. This principle, formulated in the article "Electrodynamics in Curvilinear Coordinates and the Equation of a Geodesic Line", revealed the nature of the mass of elementary particles and became the basis for the formulation of the Principle of differentiation into physical and mathematical theories.

Keywords

Origin of the Universe, Expansion of the Universe, Corpuscular-Wave Dualism, The Principle of Differentiation into Physical and Mathematical Theories

1. Introduction

The Principle of differentiation into physical and mathematical theories is formulated as follows. Physics considers only objects that really exist in nature. They are called physical objects. These are objects that can be observed experimentally. Theories constructed using only physical objects are physical theories. Objects that do not exist in nature and underlie the theories that use the mathematical apparatus are mathematical objects. Theories constructed using mathematical objects are mathematical theories.

An example of an object that does not exist in nature is the ether. Michelson's experiment, the appearance in physics of the concept of the electromagnetic field as a real physical object and the creation of the theory of relativity by Einstein—all this showed that the ether does not exist in nature.

2. Electrodynamics and the Principle of Differentiation into Physical and Mathematical Theories

One of the most important physical objects that really exist in nature, because it can be observed experimentally, is the electromagnetic field. The electromagnetic field theory, which is based on Maxwell's equations, is a well-researched area of theoretical physics known as classical electrodynamics. However, classical electrodynamics corresponding to the experimental basis of the 18th-19th centuries is directly related to a number of problems of modern theoretical physics. These problems can be eliminated if electrodynamics is brought into line with the experimental base of the 21st century. The experiments in which the laws of classical electrodynamics were discovered indicate that classical electrodynamics can be called a macroscopic theory. This confirms, for example, the concept of "point elementary charged particle" used in classical electrodynamics. Thus, considering elementary particles as point ones, classical electrodynamics neglects the complex internal structure of elementary particles. Therefore, classical electrodynamics does not correspond to the modern experimental base, which is based on colliders. The thing is that the modern experimental base requires the theory to consider elementary particles at the microscopic level, using such physical concepts as quarks, strong interaction, etc. These requirements are met by electrodynamics, described in the article "Electrodynamics in curvilinear coordinates and the equation of a geodesic line" [1]. The article [1] for the first time formulated the principle of equivalence of the electromagnetic field and the field of strong interaction to a free material particle. From this principle follows the law of formation of elementary particles from the electromagnetic field and the field of strong interaction. This law reveals the nature of the mass of elementary particles and serves as the basis for the formulation of the Principle of differentiation into physical and mathematical theories. Therefore, we will begin this article with more detailed proofs of the law of formation of elementary particles from the electromagnetic field and the field of strong interaction.

When constructing electrodynamics in curvilinear coordinates [1], an antisymmetric tensor of the second rank was used

$$f^{ik} = \frac{\partial x^i}{\partial u}\frac{\partial x^k}{\partial v} - \frac{\partial x^k}{\partial u}\frac{\partial x^i}{\partial v} \tag{1}$$

where x^i are four-dimensional coordinates, $u = x'^0$, $v = x'^1$ are curvilinear coordinates on the two-dimensional surface $x^i = x^i(u,v)$. Tensor (1) allows us to write the action integral for the electromagnetic field in the following form

$$const\iint_S F_{ik} f^{ik}\,\mathrm{d}u\mathrm{d}v \tag{2}$$

where $F_{ik} = F_{ik}(x^i)$ is the antisymmetric tensor of the second rank, describing the electromagnetic field. And S is an arbitrary region lying on a two-dimensional surface $x^i = x^i(u,v)$, which can be considered as a Riemannian two-dimensional space embedded in Euclidean space as a surface [2]. As can be seen from (1), the tensor f^{ik} in the integral of action (2) plays the role of "velocities". This allows us to obtain a full-fledged variational problem. Solving this problem, we arrive at a number of important results [1]. One of them says that the variations of the coordinates *u* and *v*, which lie in the tangent plane to the two-dimensional surface $x^i = x^i(u,v)$, are equal to zero:

$$\delta x'^0 = \delta x'^1 = 0. \tag{3}$$

Equalities (3) follow from the boundary conditions for the variational problem under consideration [1]. But they have a deeper meaning. In the classical variational problem, the variable over which the integration is performed does not vary. In our case (2), the integration is performed over two variables. Equality (3) is a mathematical notation that these variables do not vary.

In article [1], possible changes in coordinates are limited by the condition:

$$\delta g^{ik} = 0. \tag{4}$$

This condition means that the variations of the metric tensor describing the geometry of the four-dimensional space are equal to zero. Condition (4) makes it possible to exclude the appearance of gravitational fields as a result of coordinate transformation. A number of additional conditions follow from this condition. Let's find them. Let us perform the variation of the equality

$$g_{ik} g^{kl} = \delta_i^l, \tag{5}$$

Take into account condition (4), we obtain

$$\delta g_{ik} g^{kl} = 0. \tag{6}$$

This is a system of linear homogeneous equations with unknowns δg_{ik}. Since $\det\left[g^{kl}\right] \neq 0$, the system has only the zero solution $\delta g_{ik} = 0$. Hence, taking into account condition (3) and the equality $\delta x'^i = \delta x^i$, which is valid under the condition detailed in the article [1], we obtain:

$$\delta g_{ik} = \frac{\partial g_{ik}}{\partial x^{\hat{a}}} \delta x^{\hat{a}} = 0. \tag{7}$$

where $\hat{a} = 2,3$.

Since $\delta x^{\hat{a}}$ is an arbitrary value, therefore, equality (7) implies

$$\frac{\partial g_{ik}}{\partial x^{\hat{a}}} = 0. \tag{8}$$

Equality (8) means that the components of the four-dimensional metric tensor g_{ik} do not depend on the coordinates x^2 and x^3. This equality imposes significant restrictions on the geometry of the field under consideration. Therefore, it can be called a symmetry condition.

Condition (4) can also be written in the form of the Killing equations [3]:

$$\xi^{i;k} + \xi^{k;i} = 0. \tag{9}$$

where ξ^i is a small value, which is determined from the transformation from coordinates x^i to coordinates $x'^i = x^i + \xi^i$. The covariant derivative of ξ^i is:

$$\xi^i_{;k} = \xi^i_{,k} + \Gamma^i_{lk} \xi^l. \tag{10}$$

Let's simplify this definition. And we take into account the result of simplification of Equation (9): $\xi^i_{;i} = 0$. Using the definition of Γ^i_{kl}, we get:

$$\xi^i_{,i} = -\Gamma^i_{li}\xi^l = -\frac{1}{2}g^{im}\frac{\partial g_{mi}}{\partial x^l}\xi^l . \tag{11}$$

Let's compare the definition of variation

$$\delta x^i = x''^i\left(x^0, x^1, x^2, x^3\right) - x^i \tag{12}$$

with a small value $\xi^i = x''^i\left(x^0, x^1, x^2, x^3\right) - x^i$, we get:

$$\xi^i = \delta x^i . \tag{13}$$

Substituting the right side of equality (13) into (11) and taking into account (7), we obtain:

$$\frac{\partial g_{mi}}{\partial x^l}\xi^l = \frac{\partial g_{mi}}{\partial x^l}\delta x^l = \delta g_{mi} = 0 . \tag{14}$$

Thus, from equality (11) we find:

$$\xi^i_{,i} = 0 . \tag{15}$$

In article [1], the equality was obtained:

$$\frac{1}{\sqrt{-g}} = 1 + \xi^i_{,i} . \tag{16}$$

where $g = \det\left[g_{ik}\right]$.

From here, from equalities (15) and (16) we find:

$$\sqrt{-g} = 1 . \tag{17}$$

This is another consequence of condition (4).

Let us add to the symmetry condition (8) the time synchronization condition [3]:

$$g_{0\alpha} = 0 , \tag{18}$$

We obtain a very simple relationship between the spatial components of the four-dimensional metric tensor $g_{\alpha\beta}$ and the components of the three-dimensional metric tensor $\gamma_{\alpha\beta}$:

$$\gamma_{\alpha\beta} = -g_{\alpha\beta} , \tag{19}$$

where $\alpha, \beta, \cdots = 1, 2, 3$.

We take into account the condition of orthogonality of three-dimensional coordinates:

$$\gamma_{\alpha\beta} = 0 \text{ at } \alpha \neq \beta . \tag{20}$$

Applying conditions (8), (18), (19) and (20), we obtain:

$$\frac{\partial \gamma_{\alpha\alpha}}{\partial x^{\hat{a}}} = 0 . \tag{21}$$

Spherical coordinates with the value $\gamma_{33} = r^2 \sin^2 \vartheta$ do not satisfy condition (21) because

$$\frac{1}{2}\frac{\partial \gamma_{33}}{\partial x^2} = r^2 \sin\vartheta \cos\vartheta \neq 0 . \quad (22)$$

But this fact speaks only about the "features" of spherical coordinates, and not about the fact that physical systems satisfying the condition (21) cannot exist in nature. Cylindrical coordinates are an example of coordinates satisfying condition (21). In this case, it should be taken into account that all considerations should be carried out in an infinitely small region of space. This is due to the fact that g_{ik} can depend on x^0, so the spatial metric $\gamma_{\alpha\beta}$ can change over time [3]. Consequently, the concept of a definite distance remains valid only in the infinitely small. By dividing a sphere or an ellipsoid into cylinders of infinitely small height, we ensure that condition (21) will be satisfied for any of these cylinders. Since any of these cylinders can be considered in cylindrical coordinates.

Another example of coordinates satisfying condition (21) is given in the work of the author of this article [4]. Such coordinates were obtained in an infinitesimal neighborhood of an arbitrary point M lying on a sphere and having spherical coordinates $r_M, \vartheta_M, \varphi_M$. At this point the equality $\delta x'^i = \delta x^i$ is valid. Let us give an example of coordinates for which condition (21) is satisfied.

The coordinate line of the spherical coordinate φ is a circle of radius $\rho = r\sin\vartheta$. On it $\vartheta = const$ and $r = const$. Let us introduce a new coordinate θ instead of the coordinate ϑ. The new coordinate is related to the coordinate φ by the following equality [4]:

$$\sin\theta = \frac{\sin\vartheta_M}{\sqrt{1-\cos^2\vartheta_M \sin^2(\varphi_M - \varphi)}} . \quad (23)$$

This is the equation for a circle of radius $r = r_M$. A sphere of radius $r = r_M$ intersects along this circle with a plane passing through the point M and point 0, which is the origin of the spherical coordinate system. This plane is mutually orthogonal to the half-plane $\varphi = \varphi_M = const$ passing through the 0z axis. If $\varphi_M - \varphi \sim 0$ then the value $\sin^2(\varphi_M - \varphi) \approx (\varphi_M - \varphi)^2$ has the second order of smallness. Neglecting this value in equality (23), we obtain:

$$\sin\theta \approx \sin\vartheta_M . \quad (24)$$

Let us introduce a new coordinate instead of the coordinate φ:

$$\phi = \sin\vartheta_M \int_0^{\varphi_M - \varphi} \frac{\mathrm{d}(\varphi_M - \varphi)}{\sqrt{1-\cos^2\vartheta_M \sin^2(\varphi_M - \varphi)}} . \quad (25)$$

Considering that ϑ_M and φ_M are fixed values, we obtain from (25) at $\varphi_M - \varphi \sim 0$:

$$\phi \approx \sin\vartheta_M (\varphi_M - \varphi) . \quad (26)$$

The coordinate line of the coordinate ϕ is a circle of radius r_M that passes through the point M. On this coordinate curve in an infinitely small neighborhood of the point M we have $\theta \approx const$. This follows from the fact that the equation of the coordinate line of the coordinate ϕ is equation (23). Therefore, in an infinitely small neighborhood of the point M, from equation (23) we obtain equality (24). Thus, for the new coordinates θ and ϕ, the coordinate lines are circles of the same radius r_M that lie on mutually orthogonal planes intersecting along the radius connecting the points O and M. The new coordinates θ and ϕ are related to the Cartesian coordinates x, y, z by the following equalities:

$$x = r\sin\theta\cos\left(\varphi_M - \frac{\phi}{\sin\vartheta_M}\right), \tag{27}$$

$$y = r\sin\theta\sin\left(\varphi_M - \frac{\phi}{\sin\vartheta_M}\right), \tag{28}$$

$$z = r\cos\theta\,. \tag{29}$$

It is easy to check that in an infinitely small neighborhood of the point M, where relation (24) is valid, the square of the length element will be equal to

$$\mathrm{d}r^2 + r^2\mathrm{d}\theta^2 + r^2\mathrm{d}\phi^2\,. \tag{30}$$

From here we find: $\gamma_{22} = \gamma_{33} = r^2$. Therefore, in curvilinear coordinates r, θ, ϕ, equality (21) is satisfied.

The principle of equivalence of an electromagnetic field and a field of strong interaction to a free material particle formulated in the article [1] allows applying the principle of least action, which describes the motion of a free material particle, to the field geometry. By varying the integral $\int \mathrm{d}S$ and taking into account conditions (3), (7) and (8), we obtain that the components 2 and 3 of the four-dimensional acceleration are equal to zero

$$\frac{\mathrm{d}u_{\hat{a}}}{\mathrm{d}S} = 0\,, \tag{31}$$

or in covariant form

$$\frac{Du_{\hat{a}}}{\mathrm{d}S} = \frac{\mathrm{d}u_{\hat{a}}}{\mathrm{d}S} - \frac{1}{2}\frac{\partial g_{kl}}{\partial x^{\hat{a}}}u^k u^l = 0\,. \tag{32}$$

This proves that a spherically symmetric field configuration is the most preferable, since with such a configuration the action integral will have an extreme value. Consequently, the electromagnetic field and the field of strong interaction will acquire a spherical configuration. This will lead to the formation of an elementary particle. The particle will have mass and electric charge. Thus, the mass and charge of an elementary particle is a consequence of the geometry of the field. The foregoing makes it possible to formulate the Principle of differentiation into physical and mathematical theories and take a fresh look at a number of areas of physics.

3. Application of the Principle of Differentiation into Physical and Mathematical Theories to Quantum Mechanics

The brilliant results of quantum mechanics in describing the properties of the microworld overshadow one serious problem that exists in this area of physics. We are talking about the fact that quantum mechanics cannot name which physical object the carrier of the property is known as wave-particle duality. Applying the Principle of differentiation into physical and mathematical theories to quantum mechanics, we come to the conclusion that quantum mechanics is a mathematical theory. In order for quantum mechanics to become a physical theory, it is required to find a physical object with a property called wave-particle duality. This object was found in the article "Electrodynamics in curvilinear coordinates and the equation of a geodesic line" [1], this object is called the electromagnetic field and the field of strong interaction. Here the question naturally arises: what results can this lead to in quantum mechanics and in physics as a whole? The answer to this question can be found in the article "Electrodynamics in curvilinear coordinates and the equation of a geodesic line". In the article [1], two equations of "motion" were obtained for the electromagnetic field and the field of strong interaction. These equations resemble the Schrödinger equation. True, they do not include Planck's constant. But in the article [1], an unbounded field, *i.e.*, a classical problem is considered. This field consists of two fields: the electromagnetic field and the strong interaction field. This field can be the key to solving the problem of quantum gravity. After all, the components of this field are described by formulas relating the magnitude of the field with the geometry of the field. The formula describing the magnitude of the electromagnetic field is a generalized Coulomb's law for curvilinear coordinates. The second formula describes the field of strong interaction. These two formulas are reminiscent of Einstein's equations written without the right side.

4. Application of the Principle of Differentiation into Physical and Mathematical Theories in Cosmology

Knowing the nature of the mass of elementary particles and the law of formation of elementary particles from the electromagnetic field and the field of strong interaction [1], it is possible to describe in more detail the process of the emergence of the Universe and its expansion.

Let us formulate a number of important principles that allow us to describe the process of the emergence of the Universe.

Principle 1. When describing the state before the Big Bang, when there was neither time, nor space, nor matter, one must use the same physical quantities and the same physical laws that are used to describe the current state of the Universe.

Using Principle 1, the state before the Big Bang can be described as follows:

$$t = 0; \boldsymbol{r} = 0; \mathrm{d}t = 0; \mathrm{d}\boldsymbol{r} = 0. \tag{33}$$

where t is the time, $\boldsymbol{r}$ is the radius vector.

Equalities (33) allow us to formulate Principle 2.

Principle 2. The state before the Big Bang is nothing but a Point.

Equalities (33) allow us to write an expression that, as follows from Principle 2, describes the state before the Big Bang at a Point:

$$c^2\mathrm{d}t^2 - \mathrm{d}\boldsymbol{r}^2 = 0\,. \tag{34}$$

where c is the speed of light.

The expression on the left side of equality (34) is nothing more than the square of the interval element written in Point. And, as follows from equality (34), the element of the interval is equal to zero. But the zero interval describes the propagation of an electromagnetic wave in four-dimensional space. This allows us to formulate Principle 3.

Principle 3. The state before the Big Bang in the Point is equivalent to the electromagnetic wave in the Point.

Applying the uncertainty principle to the state before the Big Bang at the Point, which, according to Principle 3, is equivalent to the electromagnetic wave at the Point, we find that the energy of the electromagnetic wave at the Point can reach an infinitely large value. This is what leads to the Big Bang. From what has been said follows Principle 4.

Principle 4. The Big Bang is nothing more than a Giant Ejection of electromagnetic energy, which creates the Universe as it spreads.

The article [1] shows that electromagnetic energy includes not only the energy of the electromagnetic field, but also the energy of the strong interaction field. This, of course, will also be true for the electromagnetic energy referred to in Principle 4.

The electromagnetic energy of the Giant Ejection will propagate at the speed of light, representing a giant sphere. The leading edge of this sphere, representing the state where there is time, space and matter, will always border on the state where there is no time, no space, no matter. At this boundary, elementary particles will be born from the electromagnetic field and the field of strong interaction. The process of formation of elementary particles will occur throughout the entire time of the propagation of the energy of the Giant Ejection. And this process will continue until the energy of the Giant Ejection runs out. Following the leading edge of the spherical surface of the Giant Ejection, its central part will move. It will act on the newly formed elementary particles, accelerating them to certain speeds.

The stated theory fundamentally changes the very process of expansion of the Universe. The fact is that Hubble's law will now be valid only for elementary particles that were formed in the first moments of time after the Giant Emission of electromagnetic energy. For elementary particles that were formed in subsequent moments of time, Hubble's law cannot be applied. Let's show it using the simplest calculations.

Let us take as the origin of the spherical coordinate system the Point at which the Giant Ejection of electromagnetic energy occurred. The leading edge of the spherical surface will cover the distance $r_c = ct_c$ in time t_c. Let v_c be the radial velocity of elementary particles that appeared at the time t_c. During the time $t - t_c$ these particles will cover a distance equal to

$$r - r_c \approx v_c \left(t - t_c\right) \tag{35}$$

and will be at a distance r from the origin of the spherical coordinate system. If we apply the Hubble law to these particles, then for their speed we get the following value:

$$v \approx \frac{r}{t} \approx \frac{r_c + v_c\left(t - t_c\right)}{t} = \left(c - v_c\right)\frac{t_c}{t} + v_c . \tag{36}$$

When deriving formula (36), formula (35) was used. It follows from formula (36): 1) if $t_c \sim t$, then $v \sim c$, 2) if $t_c \ll t$, then $v \sim v_c \approx v_0 = \frac{r_0}{t_0}$. Let's consider these two cases in more detail.

We begin our consideration with the second case. Case 2) describes the speed of that part of the elementary particles that were formed in the first moments of time after the Giant Emission of electromagnetic energy. Only for these particles is the Hubble law valid, which can be written as follows: $v_0 = \frac{r_0}{t_0}$. Case 1) describes the speed of that part of the particles that were formed at later times. Hubble's law cannot be applied to these particles. Since the application of the Hubble law, see formula (36), leads to an overestimation of the real particle velocity. This is because only part of the distance r is passed by the particles, while the rest of this distance is covered by the electromagnetic energy of the Giant Ejection moving at the speed of light. Therefore, the result can be a particle speed very close in magnitude to the speed of light. Modern measurements of the expansion rate of the Universe give a similar result. This is an experimental confirmation of the validity of the stated theory describing the emergence of the Universe as a result of the Giant Ejection of electromagnetic energy and its expansion.

5. Conclusion

This article formulates the principle that is the foundation of all physics. It is shown how the application of this principle in quantum mechanics and cosmology makes it possible to find new solutions to old problems.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

[1] Parfyonov, A.V. (2022) Electrodynamics in Curvilinear Coordinates and the Equation of a Geodesic Line. *Journal of Modern Physics*, **13**, 1382-1402. https://doi.org/10.4236/jmp.2022.1311086

[2] Rashevsky, P.K. (2006) Rimanova Geometry and Tensor Analysis. URSS, Moscow, 383, 387, 445.

[3] Landau, L.D. and Lifshitz, E.M. (1980) The Classical Theory of Fields. Course of Theoretical Physics. Volume 2, Butterworth-Heinemann, an Imprint of Elsevier Science.

[4] Parfyonov, A.V. (2018) Electrodynamics in Curvilinear Coordinates. IPK "Venets" ULSTU, Ulyanovsk.