What is an electric charge?

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Popular science article

> We were waiting out a thunder storm in the Institute hall. A lightning flashed. I counted to six when the thunder rolled. I multiplied six by 300, it made 1800. Well, the lightning had struck very close by, I thought. Two girls were standing beside me. Suddenly I asked them: “Do you know how to tell the distance to the lightning?” They smiled condescendingly: “We have finished school and need this no more”. I didn’t know what to say to them.
>
> “Waiting out the thunderstorm”.

Introduction

It cannot be denied that physics is a very difficult subject, and many try to forget it like a bad dream when out of school. Why is it so? Difficulties begin immediately when defining basic physical quantities and notions. And scientists themselves realize it.

This is what R.Yu.Volkovysky writes about it in [1].

“Such fundamental notions of physics as energy, mass, charge etc. defy formal and logical definition altogether".

And he continues further in [1].

“In this connection the matter of definitions of physical quantities appears to fall beyond the scope of physics, and the methodology of introduction of definitions must be based on achievements of scientific philosophy, logics and mathematics”.

It is evident from the quote that considering the computational problems on hand, the classical physics is yet unable to, and must not, as it seems, give an unequivocal rigorous definition to basic physical quantities which it simply declares to be fundamental, that is to say, original and indefinable. Why is it so? It is probably due to complexity of objects and phenomena encountered by this science. The classical physics is largely an experimental science, and, therefore, at this point it is only in the context of a specially arranged test that we can formulate, for example, a hypothesis on the electric charge, and then give its definition with reference to this test.

The objective of this work is to consider problems of defining the notion of the physical quantity based on the study 2 and attempt to give a more or less clear formal and logical definition of the electric charge as a physical quantity of a specific self-organizing system formed by interaction of basic unified physical elements.

1 The notion of a physical quantity

The root of all problems of foundations of physics lies in the notion of a physical object (system) and its physical quantity. What is a physical quantity, from the classical physics viewpoint?

Let us quote the definition stated in the reference book [3].

" *A physical quantity* is a property which is qualitatively common to many physical objects (physical systems, their states and processes undergoing there) but is quantitatively object-specific.

In the classical physics an object is fairly often defined through a physical quantity which it must have, or be indirectly related to. For example, in the classical physics an object with a mass is defined as a material point with a mass. Nothing is mentioned about what must determine the presence of mass.

What a physical object (system) must be like to have mass is considered the article [4].

The situation is just as complex with the definition of the electric charge. It is normally defined with the help of force interaction of particles [5].

"There exist two kinds of electric charges – *positive and negative.* Interacting forces of motionless bodies or particles caused by electric charges of these bodies or particles are called *electrostatic forces*".

In other words, electrostatic forces are determined by electric charges, also it is understood that charges are detected with the help of electrostatic forces. And it is natural that electrostatic forces are different from other forces in that they are determined by electric charges. For some reason all this brings about the thought about 'sepulka' invented by Stanislaw Lem.

In modern schoolbooks, for example, in [6], one can come across such a definition of the electric charge.

"An electric charge is a physical quantity that is the source of the electric field whereby interaction of particles having the charge is effected.

This definition is more appropriate than the previous one. A more academic definition of the electric charge is given in 7.

"An electric charge is a scalar physical quantity which is a qualitative measure of electromagnetic interactions.

Nevertheless, a number of questions arise that have no answers. Why is the electric charge the source of the electric field? What is the electric field? What is the mechanism of interaction of particles with electric charge? Generally speaking, it is desirable to have a single definition of the electric charge.

One might think that the way of the vicious circle would be to define the electric charge as a property of the electron. The following definition of the electric charge is given in [5].

"The electric charge of any system of bodies consists of integer number of elementary charges approximately equal to $1{,}6 \cdot 10^{-19}$ coulomb…. *The electron is* a stable particle with the smallest mass having a negative charge."

I.e. the electron is that very object with the electric charge which determines "*electrostatic forces".* But immediately we have a justified a question to ask: "What is so particular in the electron structure that determines the presence of this specific property – the electric charge"? Or, in other words, what should be the property of a physical object that is "qualitatively common to many physical objects" (in terms of structure, construction, composition) for it to have the physical quantity *electric charge*?

The classical physics has no unified structural definition of objects, i.e. the one saying that any complex physical object could be created, constructed from a minimum number of elementary unified physical objects and have a corresponding physical quantity.

Therefore, in order to give a formal and logical definition of any physical quantity, it is required that any physical quantity is determined by a structure, construction or geometry and composition of a physical system, of unified physical elements included in the system.

Consequently, we must define what should be the necessary structure and composition of a physical system for it to have a physical quantity - electric charge.

2 Unified physical elements

Geometric objects may be the most suitable objects serving as a specimen for construction of unified physical elements. Geometric objects, or subsystems of the physical space, and their quantities are extensively used in physics – it's a point (or a number), a line (a trajectory), a plane or a surface (a membrane), three-dimensional bodies (a ball, a cube etc.). Physical quantities of geometric objects are length L, area S, volume V. That is to say, every geometric object can be associated with its quantitative characteristic. Also, there exists simple mathematical interrelation between geometric quantities expressed in the form of formulas:

$n = L^0, l = L^1, S = L^2, V = L^3$ where n – a number. For a geometric quantity of any dimension the common formula takes the following form: $\Phi = f(x_1 x_2 \cdots x_N) L^N$, where N is the dimension of space, while $f(x_1 x_2 \cdots x_N)$ is the function that determines the shape of a geometric object.

It is natural to view space, time, substance, electromagnetic and gravitational fields as basic unified elements of physical systems. In order to build physical systems with a mass or electric charge feature etc., it would appear reasonable to assume that all our basic elements interact with each other thereby forming a self-organizing system – a physical reality, or Universum. The study [2] formulates postulate №1 on self-organization of the physical reality.

Postulate №1

"*The surrounding physical reality is a uniform self-organizing physical system".*

Since the classical physics attributes to space and time another, non-system physical meaning, where "space and time are the form of existence of matter", basic subsystems of Universum will then be called the geometric space and astronomical time, respectively.

Therefore, *the geometric space* and *astronomical time* are basic subsystems of Universum.

These basic subsystems, in turn, consist of unified physical elements.

Unified physical elements of the geometric space are *multi-dimensional cavities* $D_{\Gamma\Pi}^{\pm\alpha}$.

Unified physical elements of the astronomical time are *multi-dimensional intervals* $D_{AB}^{\pm\beta}$.

However, it is evident from daily experience that Universum cannot consist only of the empty geometric space and ongoing unchanging astronomical time because it must enclose certain objects tangible in space and events detectable in time.

Some cavities of the geometric space must be filled with "substance" (spatially similar substance) whereas some of the intervals must be filled with occurring "events" (in the form of time condensations, or similar ether time).

"Substance" and "events" as basic subsystems of Universum will be called *material substance* and *chronal ether,* respectively.

Therefore, the *material substance* and *chronal ether* are also basic subsystems of Universum.

Unified physical elements of the material substance are *multi-dimensional granules* $D_{BC}^{\pm\delta}$ which can occupy separate *multi-dimensional cavities* of the geometric space $D_{\Gamma\Pi}^{\pm\alpha}$.

Unified physical elements of the chronal ether are *multi-dimensional pulses* of the chronal ether $D_{X\Theta}^{\pm\gamma}$ which can occur in separate *multi-dimensional intervals* of the astronomical time $D_{AB}^{\pm\beta}$.

3 Unified physical quantities

The following notions are introduced in the study [2].

1) Geometric space (ГП) consisting of physical elements – continuous multi-dimensional cavities $D_{ГП}^{\pm\alpha}$ which are comparable to the space of the classical physics and constitute a spatial component of the gravitational and photonic (electromagnetic) fields.

Multi-dimensional cavities $D_{ГП}^{\pm\alpha}$ must have dimensions α equal to: 1, 2, 3, 4, or 5 and corresponding unified physical quantity (frame) $L_{Г}^{\pm\alpha}$.

2) Material substance (ВС) consisting of physical elements – discrete multi-dimensional granules $D_{ВС}^{\pm\delta}$ which are accommodated in ГП cavities and constitute a inert and electric matter (electricity) component filling ГП cavities.

Multi-dimensional granules $D_{ВС}^{\pm\delta}$ must have dimensions δ equal to: 1, 2, 3, 4, or 5 and corresponding frame $\pm i^{\pm\delta} L_{И}^{\pm\delta}$ where i is an imaginary unit known in mathematics $i = \mp\sqrt{-1}$.

3) Astronomical time (АВ) consisting of physical elements – continuous multi-dimensional intervals $D_{АВ}^{\pm\beta}$ which are comparable to the classical physics time and constitute a time component of the gravitational field and electric matter.

Multi-dimensional intervals $D_{АВ}^{\pm\beta}$ may have dimensions β equal to: 1, 2, 3, 4, or 5 and corresponding frame $T_{Г}^{\pm\beta}$.

4) Chronal ether (ХЭ) consisting of physical elements – discrete multi-dimensional pulses $D_{ХЭ}^{\pm\gamma}$ which occur (originate, continue and end) in АВ intervals and constitute a component of the photonic field and inert matter occurring in АВ intervals.

Multi-dimensional pulses $D_{ХЭ}^{\pm\gamma}$ must have dimensions γ equal to: 1, 2, 3, 4, or 5 and corresponding frame $\pm i^{\pm\gamma} T_{И}^{\pm\gamma}$.

The notion of a physical complex is introduced in the study [2].

A physical complex is an object formed as a result of the system integration of various physical elements.

Four types of physical complexes are formed as a result of system orthogonal integration of basic subsystems' physical elements:

1) $D_{ГП}^{\pm\alpha} \otimes D_{АВ}^{\pm\beta} = D_{ГР}^{\pm\alpha,\pm\beta}$ – gravitons of the gravitational field;

2) $D_{ГП}^{\pm\alpha} \otimes D_{ХЭ}^{\pm\gamma} = D_{ФТ}^{\pm\alpha,\pm\gamma}$ - photons of the photonic field;

3) $D_{ВС}^{\pm\delta} \otimes D_{АВ}^{\pm\beta} = D_{ЭЛ}^{\pm\delta,\pm\beta}$ - electrions of the electric matter;

4) $D_{ВС}^{\pm\delta} \otimes D_{ХЭ}^{\pm\gamma} = D_{ИН}^{\pm\delta,\pm\gamma}$ – inertions of the inert matter.

Two axioms are introduced.

Axiom №1

The ratio $\lambda^{\alpha} = L_{Г}^{\alpha} / i^{\alpha} L_{И}^{\alpha}$ is a fundamental system constant.

Axiom №2

The ratio $\tau^{\beta} = T_{Г}^{\beta} / i^{\beta} T_{И}^{\beta}$ is a fundamental system constant.

Then the gravitational constant will take the form: $G = \lambda^{3} / \tau^{2}$.

The electric constant will take the form: $\varepsilon_0 = 1 / \lambda^{3} \tau^{2}$.

4 Definition of the electric charge

By using physical elements and unified physical quantities, or frames, we can now define not only the electric charge, but also a physical system having this property.

Let us consider the equation known in the classical physics

$$m \cdot a = q \cdot E, \qquad (1)$$

where
m – mass,
a – acceleration,
q – electric charge,
E – intensity of the electric field.

In article [2] we determined the mass frame which takes the form $m_{И} = \pm i\ L_{И}^{3} / T_{И}^{2}$. It is obvious that the acceleration frame will take the form $a = L_{Г} / T_{Г}^{2}$. Now, if these frames are substituted in the expression (1), we shall then obtain:

$$\frac{\pm i L_{И}^{3}}{T_{И}^{2}} \cdot \frac{L_{Г}}{T_{Г}^{2}} = q \cdot E \qquad (2)$$

If positions of denominators in the left side of the expression (2) are interchanged, the equality will be preserved, owing to the commutative feature of multiplication.

After the permutation we shall obtain:

$$\frac{\pm i L_{И}^{3}}{T_{Г}^{2}} \cdot \frac{L_{Г}}{T_{И}^{2}} = q \cdot E \qquad (3)$$

Using the similarity principle, one can consider the inert mass to be similar to the electric charge, so it will be logical to identify the first cofactor in the equation (3) with the charge, while the second cofactor - with the intensity of the electric field.

Now it is readily seen that the frame of the charge will take the form $q = \pm i L_{И}^{3} / T_{Г}^{2}$, while the frame of the electric field intensity will take the form $E = -L_{Г} / T_{И}^{2}$.

It is readily seen that the formula of the electric charge is similar to the formula for mass whereas the formula of the electric field intensity is similar to the formula of acceleration.

5 The physical meaning of the electric charge

Since there is one-to-one correspondence between physical elements and frames, we can then define a complex that must have electric charge. It will be an electrion formed through interaction of a three-dimensional granule of the material substance with reverse two-dimensional interval of the astronomical time. A symbolic formula of this electric matter complex will take the form: $D^{3}_{BC} \otimes D^{-2}_{AB} = D^{3,-2}_{ЭЛ}$

One can assume that the physical meaning of the electric charge is that it is the feature of a material substance three-dimensional granule oscillating with a certain time period the square of which is equal to two-dimensional interval of the astronomical time.

Conclusion

Now we know another definition of the electric charge. We have new possibilities to perceive the physical reality, for example, we can now easily prove the theorem on charge and mass interaction [4], and the question of what the electric charge is, has become no more difficult for us than how to tell the distance to the lightning? Stop waiting out the thunderstorm, we have a long way ahead.

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