Remarks on foundations of physics

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Abstract: A simple scheme for ordering the facts of physics is presented, and some terms associated with basic research are introduced. Some aspects of this research are discussed and an outline of a simple model as an example of a working hypothesis for explaining the known facts is proposed.

1. Introduction

Perhaps every physicist more or less frequently drifts in his thoughts from very specialistic issues dealt with by himself daily towards more fundamental questions at the border of the present physical knowledge and of our understanding the material world we live in. However, there is an impression that this kind of issues is not getting a due attention and does not find an adequate place in practical research. On one side there exists the philosophy of science where on the basis of logic and epistemology some issues of this kind are being solved, but the approach is so formalistic that it does not reach the average physicist. Reading of such a work like e. g. that of Stegműller [1] a physicist is full of admiration but practically it does not influence his research work at all. On the other hand, physicists themselves express their opinions about such basic subjects rather rarely and reluctantly, sometimes on seminars which are regarded to be not fully serious, in popular-scientific works or in lectures on such occasions like a jubilee of scientific activity or awarding a prize. An unwritten social code says that it is necessary to be a physicist of a very high rank in order to be allowed to take up such a subject. But it seems that the opposite should be right. Those fundamental questions shall occupy the mind and be of deepest concern to every physicist involved in basic research.

In this work an attempt to formulate some terms and issues in an informal, possibly straight and concise way is made. Formalists will be disgusted by understatements, the absence of strict definitions and fragmental character of the topics addressed but the objective is not to build a theory but only to turn attention to some issues which seem to be essential for a progress in understanding the facts which constitute the foundation of the current physical knowledge.

2. The causal structure of physics

Like every natural science physics investigates and describes a certain field of phenomena which occur in nature and formulates laws ruling these phenomena. Both the phenomena, and the existing relations between them, expressed by laws, let us call facts. Let us introduce the following simple definitions:

— The knowledge of a fact is the awareness of its existence.
— Understanding a fact is an ability to answer the question "why?".

So a given fact is known, if on the basis of experimental evidence or a generally acknowledged theory we accept its being a real phenomenon. The fact is understandable if we are able to point to some other fact which is his cause, that is which this first fact results from.

For example, asking: "Why is an apple falling down to earth?" we can give the answer: "Since the Earth and the apple attract one another". Hence, the fact "The apple is falling down to earth" is an understandable fact, since we are able to give another well-known fact, being its cause. Asking next "Why the Earth and the apple attract one another", we can answer: "Since all material bodies attract each other". This new fact is a cause of both previous, so both previous facts are a result of the fact that "All material bodies attract each other". To every fact it is possible to assign a set of facts which are its consequences.

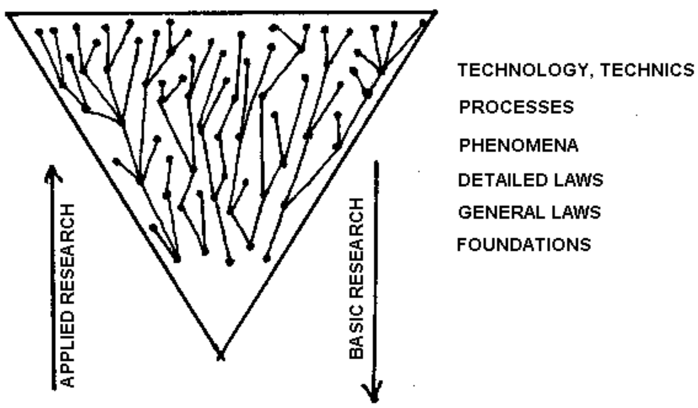

Fig. 1. "Field of facts" of physics

Figure 1 shows schematically a set of all facts relevant to physics. Individual facts are points inside a triangle. The ordering of facts inside this triangle is such that the cause always lies lower than its consequence. Upon such assumption one can distinguish on the surface of the triangle of facts certain horizontal zones which contain facts of a certain character, as shown on the right-hand side of the triangle. There are no definite borders between those zones and hence the passage from one zone to another is smooth.

Taking an arbitrary fact e. g. in the zone of phenomena and answering the consecutive questions “why?” we are going down on the triangle to facts which are more general. This can be shown by straight lines which connect the correspondent facts.

The objective of research is finding new facts so far unknown, and looking for understanding of facts already known. Applied research can be regarded as seeking of consequences of facts already known and can be depicted on the triangle as a move in the upward direction. On the other hand, basic research is essentially seeking of causes of facts already known and can be depicted on the triangle as a move in the downward direction. Since individual facts have generally many consequences, while moving upward we find many ramifications and the density of facts increases. As a result of research the area of known facts expands gradually both in the upward and in the downward direction. A step upward is an invention, i. e. a discovery of an utilitarian character, while a step downwards is a discovery of a basic character. A step downwards, i. e. finding a cause of a certain fact, is meaningful for the increase of knowledge only if the cause has more consequences than the fact.

Despite our lack of understanding of many facts physics is very useful because we can find and make use of consequences of known facts without knowing their cause. Thanks to this physics develops very fast and changes our way of life although many fundamental questions remain unanswered. Nevertheless basic research is of extreme importance and should be the subject of our deep concern.

Since our considerations are devoted to the foundations of physics, we will henceforth turn our attention only to the most lower part, close to the bottom vertex of the triangle of facts. Let us call this part basic area.

3. Structure of the basic area

Starting at an arbitrary fact and descending down to successive causes we arrive finally at a fact the cause of which is unknown. This is the first fact of the causal sequence. It is a known fact but we do not know the answer of the question “Why?” This fact is known but not understood. Let us call such a fact a basic fact. For the example given in section 2 such a fact is the existence of the law of gravity. A set of all basic facts determines the recent state of knowledge. From the definition of basic facts it follows that there are no known facts below the basic facts. Hence, we can draw a line so that all known facts are above this line. This line represents the limit of our present knowledge (Fig. 2). Similarly we can draw a line which represents the limit of our present understanding. Between the limit of understanding and the limit of knowledge lie only the basic facts. The lines which intersect the limit of understanding are the first segments of the causal sequences. Below the limit of knowledge there are no any known facts. The limit of knowledge is not intersected by any line of causal sequence.

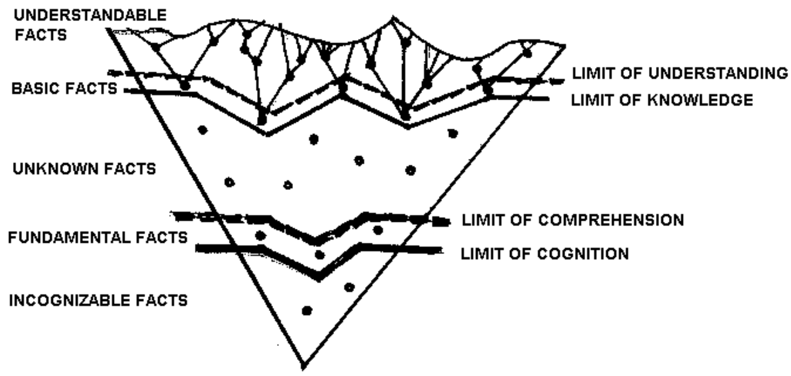

Fig. 2 Basic area of the field of facts

A basic discovery is a discovery of a hitherto unknown fact which lies below the limit of knowledge. As a result of such a discovery both the limit of understanding and the limit of knowledge shift down. The set of basic facts is changed. Hence, due to basic research the two limits move gradually downwards toward the bottom vertex of the triangle of facts.

We can now ask, what is the end of this process, i. e. what are the limits of our cognitive possibilities. Not penetrating deeper into the nature of this problem, it is possible to assume the existence of two more limiting lines: the limit of comprehension and the limit of cognition. They would represent the ultimate border of our human knowledge. The area between those two limits will contain a set of facts which let us call fundamental. If we reach sometime in our research this border of our knowledge, the limit of understanding will reach the limit of comprehension, and the limit of knowledge will reach the limit of cognition. The set of basic facts will then be identical with the set of fundamental facts. The entire physical reality will then follow from the set of fundamental facts and further continuation of basic research will be meaningless. This would be the “end of the way” which physicists are starting to speak about [2]. From this consideration a conclusion follows that ultimately we might be able to know everything but we never will understand everything. We will still be lacking the answer of the question “Why?” with regard to the fundamental facts.

4. Research in the basic area

These conclusions are right only if the accepted scheme is right. In particular, there is a question, whether the field of facts is indeed a triangle and whether it is closed at the bottom. It seems doubtless that the zone of phenomena is wider than the zone of detailed laws and the last one wider than the zone of general laws, that is the field of facts is narrowing downwards. Its shape in the basic area is one of important issues to which attention should be devoted in the strategy of basic research. It is of course not only a purely physical issue but we enter at this place also into the realm of logic, philosophy, and even psychology and aesthetics. It seems that we moved downwards the triangle of facts sufficiently deep in order to approach the strategy of basic research systematically, with necessary complexity, and with adequate means.

Here it is worth noticing that many other branches of natural science like chemistry, astronomy, cosmology, geology, biology, etc., the fields of facts of which could be depicted in a similar way, do not have their own basic facts but very often their causal sequences enter at a certain stage into the field of facts of physics and have their beginning at one of the basic facts of physics. Consequently, the present set of basic facts of physics does not characterize only the present state of knowledge in physics but to a large extent the present state of human knowledge of the universe in general.

Because of that it seems to be necessary to take up comprehensive research and analyses in the basic area. Particularly, the following subjects may be mentioned:

1. Research on the set of basic facts which could involve the introduction of systematics of known facts, formulating the conditions of basicity, formulating individual basic facts, investigating their mutual causal independence, creating lists of basic facts for individual branches of physics, comparing and supplementing them, and studying general properties of this set;

2. Research on basic discoveries, analyzing conditions and criteria for a discovery to be a basic one, formulating recommendations and instructions for proposing hypotheses and models in the area of unknown facts, evaluating the suitability and value of hypotheses and models proposed;

3. Research in the area of unknown facts, formulating general rules which are to be postulated for such facts, formulating general characteristics of causal relations by which these new facts should be connected to known facts;

4. Research related to the limit of comprehension and the limit of cognition and to the set of fundamental facts, their existence, their number, and their general properties, as well as analyzing of individual basic facts from the point of view of their possible fundamentality;

5. Formulating hypotheses, models and suggestions in the area of unknown facts with the aim to discover new basic facts, with the use of results of research specified above.

It seems that the topics mentioned deserve proper attention because such investigations and their results would be a unifying and coordinating factor in efforts and searches which up till now are being carried out mostly individually or in small groups without a broader knowledge of the problem and without a common exit point.

5. Characteristics of a basic discovery

Below a few rules for hypotheses of new facts which aim at shifting down the present limit of knowledge are proposed.

1. New basic facts must result in the reduction of the number of basic facts or in a substantial increase of the number of known facts;

2. New basic facts must present an image of reality which is as much as possible simple, symmetric, visual and beautiful;

3. New basic facts do not have to fulfill any conditions which follow from other basic facts.

Re 1. This condition is the consequence of the fact that we consider an answer to the question "why?" reasonable only if the cause has a larger set of consequences than its consequence. Hence, if the number of known facts (not including the new basic facts) remains unchanged, the number of basic facts has to decrease. On the other hand, if the number of basic facts remains unchanged, this rule 1 demands that the new basic facts are exit points of new causal sequences with a number of facts earlier unknown. In the first case the condition is fulfilled by the reduction of the number of basic facts, in the second case by an increase of the number of known facts.

Re 2. While rule 1 is objective and definite, the formulation of the second one is subjective and can stir up controversy. It originates from the conviction that up till a certain moment all great discoveries were in their essence introductions of simple, demonstrative models which could be easily grasped. When we talk about the model of planetary system by Copernicus or the model of the atom by Niels Bohr, their significance is most often stressed in categories of the point 2 and little attention is given to the question by how many they reduced the number of independent parameters. The significance of a model lays in the fact that its visuality enables a quick and simple searching for and checking of consequences, whereas its measurability lays in the fact that it joins many independent parameters into one common fact. For example, the orbit of a planet is characterized by: the length of its large semi-axis, three components of the vector of its direction in space, its eccentricity and its slant towards the ecliptic. They are independent parameters, but nobody is worrying that they are so many, because their necessity originates logically from one demonstrative fact that the orbit of the planet is an ellipse.

The departure from models was initiated by Maxwell with his very beautiful theory, which he treated however purely descriptively in accordance with the maxim "hypothesis non fingo", and in the same direction went the authors of the theory of relativity and quantum mechanics. Their theories describe perfectly the physical phenomena and this is their paramount significance, but many physicists consciously or subconsciously are sensing that authors of these theories went a bit too far in their absolutization of the relativity and in their determination of promoting the indeterminism [3, 4]. They argue that since we left the area of phenomena, accessible to our senses, the appealing to our imagination lost its justification. Many physicists, however, see in the lack of visuality a certain crisis of understanding. In this situation we have answers to the question "why?", but often they have for example a form as: "because in equation [47] the quantity Q appears with the exponent k ". This seems to show a necessity of introducing of some kind of definition of understanding and comprehensibility, i.e. a necessity to put some limitations on acceptable answers to the question "why?". In a common sense understandable is what penetrates to our conviction, whereas convincing is what can find its way to our imagination.

Re 3. Taking it formally, the rule 3 is obvious, because individual basic facts are by definition mutually causally independent. The practical significance of this point is that when proposing new facts (that is formulating new hypotheses and/or models) it is very hard to be free from an erroneous notion that the characteristics of these new facts have to obey some rules or laws which apply to other known facts. Since they are new facts, being causally independent of all other known facts, their characteristics can be completely different even from those most obvious characteristics of other known facts. Exaggerating a little, reality below the current line of knowledge can be completely different from reality in the area of facts above this line. In other words, these new facts are not to be bound by any other law pertinent to other basic facts. There is only one demand, that these known laws must appear in the causal sequences at least above the current limit of knowledge, i.e. the known reality has to be a consequence of this new basic reality. In the past, while progressing in knowledge, i.e. while penetrating deeper on the triangle of facts, it was often necessary to abandon some known laws or to limit their realm of applicability and without doubt the same will be necessary also in the future. When observing certain new hypotheses and proposals, one gets often an impression that their authors could not overcome some problems because they did not free themselves in a sufficient degree from the barrier of different unnecessary restrictions.

6. Outline of a model of unknown facts

Physicists who satisfy themselves with a mere description of phenomena try to formulate the set of basic facts in the form of a universal equation or a set of equations, which would combine all known kinds of interactions, and hence would describe the entire known reality. The supporters of visuality in physics do not have anything against these efforts, would like however to express their wish that these universal equations be a description of reality accessible to human imagination. In other words, they would like that the known reality results not from a mysterious mathematical formula, but from a transparent, demonstrative model.

In order to stimulate imagination and encourage the discussion of fundamental issues also in categories of a model, we present below a simple hypothetical model of reality below the current border of knowledge. It is not a finished model and in this form it interprets only a few basic facts qualitatively, but it can turn out to be useful as an exit point for searches of this type. Its general formulation is the following:

1. Space is filled with objects, moving in all directions rectilinear with a constant velocity. Let us name these objects actons (from the word action).

2. Actons are carriers of a certain amount of one or of a few physical quantities.

3. Only local interactions between actons exist.

4. Physical objects are local anomalies of the density of actons or of the densities of physical quantities carried by them.

Re 1. For the description of known interactions the introduction of two, and perhaps even four kinds of actons would probably prove to be necessary. The velocity of their motion must be almost certainly the velocity of light. Of course this requires the existence of a privileged state of inertial motion in which the velocity of actons is isotropic. This seems to contradict the most universally accepted interpretation of the special theory of relativity, but fortunately an alternative interpretation exists. In the Lorentzian interpretation of relativity such a privileged state of inertial motion exists, although we do not have the possibility to identify it. An opponent of the "absolutization" of relativity, Jánossy, discussed this matter extensively in his book [5]. As a matter of fact, in accordance with rule 3 from section 5 it would be even possible to allow violating the special theory of relativity on this level, requiring only that the Lorentz transformation emerges in the set of consequences of this model.

Re 2. It seems most probable that the fundamental quantity carried by actons is momentum. While penetrating material objects actons are being absorbed or lose a part of their momentum. Because of that in the vicinity of material objects a “field” exists, which consists of the anisotropy of the number of actons or of the momentum carried by them. If in the region with such an anisotropy another material object exists, the interaction of actons with this object will be also anisotropic and consequently this object will begin to move, which will manifest itself as an attraction or a repulsion of these two objects. In the light of the rule 3 from section 5, from the fact that actons have a certain momentum does not follow that they must have also mass or energy since actons are not particles or photons in the sense of presently known physical laws. In the beginning it is better not to identify the quantities carried by actons. Only after modeling of particles and their properties it will be possible to determine these quantities in units of known quantities. Because of symmetry reasons, if necessary, the kinds of actons will have to be joined in pairs, e. g. with positive and negative sign of the quantity in question.

Re 3. The locality of interactions between actons explains visually the abstract notion of a field. Interactions between actons can involve scattering, annihilation or creation of actons, or a mutual interchange of physical quantities carried by them.

Re 4. According to this model there exist nothing but the actons. It seems to be tempting to introduce a second kind of objects, the passons (from the word passive), being in the rest or moving slowly. It is easier then to form particles, but their mass spectra and charges are continuous, and the existence of spin is not a necessity. Moreover, the model demands then many additional assumptions (accepting many new basic facts) which destroys its simplicity and universality.

The adjusting of the suggested model to reality should be carried out by establishing facts not yet defined, both qualitative and quantitative ones. The most essential qualitative facts would be: kinds of actons, kinds of physical quantities carried by them, and kinds of their interactions. The quantitative facts to be established in the framework of this model are: number of actons of individual kinds in a volume unit of space, the amounts of physical quantities carried by them, the cross sections of individual interactions and the amounts of physical quantities transferred in them.

The way of acting at fitting the model to known reality is obvious. First one should ensure the stability in time of the (homogeneous) acton field itself. Next, assuming an anomaly of the density in the acton field, one should through the selection of proper interactions ensure its stability in space and time, that is, to create the particle. Next one would have to model the law of inertia for this particle, i.e. to express the inertial mass in terms of the parameters of the acton model. Then the known kinds of interactions between particles should appear. It seems, that because of the short range of strong interactions, it will be possible to model them by means of scattering of actons or by means of exchange of the quantities carried by them. On the other hand, interactions the force of which decreases proportionally to the inverse square of the distance seem to be caused by absorption of actons or of physics quantities carried by them.

If the acton model is capable to describe the known physical reality, then at a certain stage of modeling consequences in the form of well-known facts and the relations between basic well-known facts will start to appear. The present assumptions of the model aren't of course in all details binding and in the course of modeling a need for their alteration can appear.

7. Conclusions

It is not our objective to argue that by means of the proposed model it will be possible to describe all known facts. It seems, however, that rejecting it, i.e. to prove that there is no way to reconcile it with known facts regardless of the shape of the model is not a trivial task.

It is worthwhile reminding, that the concept of ether in the form of a gaseous substance turned up in the history of physics repeatedly, especially in attempts of visual understanding of gravitational and electrostatic forces. Feynman and others [6] gives an example from the year 1750 and rejects such a possibility on the grounds of violating the law of inertia. However it would be sufficient to assume an appropriate velocity dependence of the absorption cross section of the hypothetical objects (the actons) in their move inside matter in order to retain the law of inertia. Moreover, considering the motion of a body in such a "medium" one easily comes to the conclusion that the body should resist the change of its velocity, which would be a qualitative explanation of the phenomenon of inertia. Also the equivalence of inertial and gravitational mass is almost obvious in this model, similarly as the equivalence of gravity and acceleration, which follows from the general theory of relativity. Very obvious is also the statistical character of interactions in the microscopic scale, the probabilistic element in the determination of positions of particles, and many other quantum mechanical effects. Farther, since absorption of actons is described by an exponential function, the accurate formula for a force acting between two bodies can be expanded into a series of interactions with decreasing force which presents a potential possibility of unification of the electric, weak, and gravitational interactions.

Attempts to develop the acton model lead to surprising results in the form of very large densities of different physical quantities (carried by actons) in vacuum, there exists however no definite argument for the rejection of such results in advance.

The reason for which the concept of a gas-like ether was rejected many times in spite of its tempting possibilities, lies probably in the lack of awareness of the rule presented in point 3 of section 5. Not going into detail, one can say that in the first stage of elaborating this concept it is very hard to maintain the law of energy concervation if for those moving objects (the actons) all properties of regular particles are being assumed. However, admitting that actons are physical objects more fundamental than particles and hence do not have necessarily to obey the laws of mechanics of particles, may open the way for solving the initial difficulties of this concept. If this is right, then the law of conservation of mass and energy will probably prove to be a secondary law which appears in the set of consequences on the level of particles. Then mass and energy will probably turn out to be the measure by which the interaction of actons with particles can be expressed quantitatively.

The usefulness of the proposed model will of course depend on consequences which will be possible to derive from it. In its preliminary, initial form one can only say that as long as all possibilities of explaining well-known facts with the help of this or any other model would not be exhausted, the possibility of returning in physics to full visuality and understanding will be still an open question.

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