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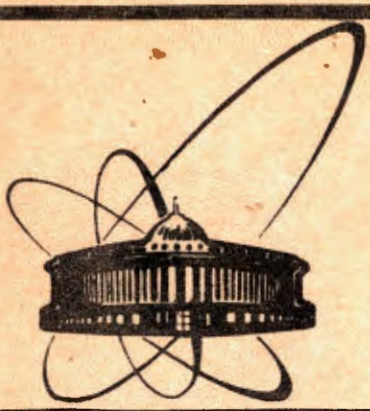

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E2-92-292

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THE MODERN OUTLOOK AT THE FOUNDATIONS OF PHYSICS AND ITS FUTURE

*The Russia State Committee for Education,
Moscow, Russia

1992

1. One of the main aims of the philosophy of science is to find keys to understanding the indivisibility and universality of civilisation.

The most fruitful way of achieving it is based on the conception of universal evolutionism. Within the conoeption, we can differentiate three levels of such universality: that of knowledge and culture, that of natural sciences, and that of physics as a basis of natural sciences.

Let us now concentrate on natural sciences and physics as such. Nature is a unified whole. That is why the study of it ought to be based on a unified foundation. It is physics that could serve as such a foundation. So we must oonsider physios as an unified science and find its connections with the other natural sciences both for the present and for the future. The point of departure in our analysis is the problem of the existence of nature in time. Already Aristotle realized the fundamental role of time differentiating the two types of time: time as "movement" (kynesis) and time as "birth and death" (metabole), taken together they reflect the properties of the universal time of nature.

The history of science shows that experience is not the only source of theoretical knowledge. Any theoretioal researoh is done within the framework of general notions of nature which is illustrated by Aristotle's views of time. These general conoeptions of nature may be called fundamental paradigms of natural sciences.

Within the framework of universal evolutionism there are two fundamental paradigms to which the two types of Aristotle's time correspond. I mean first the paradigm of movement of Newtonian paradigm whioh was originated by Democritas and second the paradigm of evolution or Darwinian paradigm whioh was originated by Plato. According to the first paradigm the macroscopic properties of material objects are determined by the microscopic properties, and are independent of the history of their origin. Conversely, according to the paradigm of evolution, the microstate of a system defines its macrostate (not only at the present moment, but also at the preceeding moments). These paradigms of natural soiences are alternative and mutually complementary.

2. The notion of a fundamental paradigm supplies us with a basis for analysing natural sciences as a whole. We can assume that

the paradigms of movement and of evolution are realized in modern physics and in modern biology respectively. Thus, the development of physics during the last three hundred years have not gone beyond Newtonian paradigm. According to I. Prigogine we should call it the physics of the being.

The main point in our analysis is the philosophical category of the physical image of nature or PIN for short. In other words it is the most general theoretical model of physics as a whole. The PIN is a hierarchial system. Its highest and most abstract level incorporates fundamental notions, principles and structures common to the majority of physical theories.

In the history of physics, there have been known different criteria for choosing the PIN. But all those have proved to be limited and methodologically useless, for they reflected only separate qualities of physics within Newtonian paradigm, and not the complete complex of its notions. Within the conception of universal evolutionism, we suggest formulating a principle of the completeness of physics as a science (adequate to Newtonian paradigm). We suggest this as a criterion of the choice of the PIN. Of course, such a criterion could have been suggested a century or three ago. However, the conditions for its conscientious use have arisen only recently. Nowdays the stability of fundamental physical theories has been established. So there is a precondition for a completely conceptualized outlook of nature.

According to the criterion, the task of discovering the PIN is limited to discovering a conceptual core of modern physics as a whole. Today many physicists and philosophers reject altogether the possibility of discovering such a core. Their scepticism can be explained by their limiting themselves to the properties of nature in the microcosm, instead of analysing the whole complex of the notions of physics within Newtonian paradigm.

3. The problem that has arisen may be solved by applying the principle of ascending from the abstract to the conorete one. The principle is an important element of the theory of cognition. Especially when we have to deal with multi-level branched science which is considered a unified indivisible entity. According to the principle, we can find PIN, if we accept as a conceptual core a unified (if abstract) model of modern physics as a whole.

The main idea of such a "completely conceptualized" (or "quantum-generalized") approach is the one formulated by P.Dirac in the thirties. It enables us to analyse the physics of the being

as a unified science. Now the time has come for it to be recognized universally by scientists. The basis of the approach is the following statement. A fundamental notion in the physics of the being, is a physical quantity, measured experimentally. That is why, this notion should be taken as its conceptual core.

Further analysis shows us the following. In practice, we always have to deal with a mean or expectation value of a physical quantity. This notion unites the two components: the physical quantity as such (or observable) and the state of the physical system, conditioned by the terms of the experiment. The observable is characterized by a set of possible experimental values. Conversely, the state is characterized by a distribution of these values. As a result, we choose the fundamental triad "the observable - the state - the mean (for expectation) value", as a conceptual core of the physics of the being. It is a decisive step towards a complex description of physics in the macro and microcosm in full accordance with Newtonian paradigm.

4. With such a basis as a conceptual core it is not difficult to formulate a modern PIN. The latter might be termed "a completely conceptualized PIN" of "a quantumgeneralized PIN ". It represents a combination of conceptions, theories and structures, which make up such an abstract triad as "the physics of the observables - the physics of the states - the physics of the mean values". Now, what remains to be done is to see how the existing physical theories are distributed over the elements of the triad. With this purpose in mind, let us subdivide original theoretical construction in its components, and then discuss them, one by one, taking each of them separately. Thus, to consider "the observables" as such, we have to limit ourselves only to such experiments, in which the observable date always have one and the same value after repeated measurements. In other words, the dependence of the mean value of a physical quantity on the state of the physical system is not evident. That is just the case with the relativistic classical physics of particles and fields, if and when both theoretical and practical complications (connected with quantum and statistical laws) are insignificant.

Next, to consider "the states of a system" as such, we have to take into account only the situations, where the state of a system can manifest itself. To achieve this, we have to show the possibility of existing of such experimental conditions, under which the observable date may (with equal probability) assume any values. That is just the case with quantum physics.

Now let us consider a synthesis of the elements of the triad into one single notion of a mean value of a physical quantity. For that, we must take into consideration first that the observable may take various values and second, that the state of a system may well be "mixed" and not "pure". Both these two elements define together a physical quantity being measured experimentally which is achieved within statistical physics. As a result, we see a correspondence between a triad of an abstract "completely conceptualized" PIN and an equivalent triad of a concrete PIN, the relativistic classical physics - the quantum physics - the statistical physics.

5. The suggested approach to choosing both a PIN and a conceptual core of "the physics of the being" allows us to solve (in a new way) a number of other methodological problems of natural sciences. Let us consider in particular the scale of revolutions in physics within Newtonian paradigm. There are three levels of generalization referring to the creation of

1. a fundamental theory,
2. an element of a fundamental triad,
3. the fundamental triad as a whole.

The three levels of revolutions in physics correspond to these three levels of generalization. So the creation of classical mechanics by Newton or of electrodynamics by Maxwell are both revolutions of the first order. The creation of the basis of relativistic classical physics by Einstein and of statistical physics by Gibbs are both revolutions of the second order. At last, the forming of the fundamental triad, (fully adequate to Newtonian paradigm) which was begun by Dirac and which is about to be finished nowdays, - this is a revolution of the third and highest order.

Keeping this in mind, the discovery of Gibbs is no less important, than the discovery of Einstein. Both the discoveries have led to a subsequent description of one element of the fundamental triad. At the same time, the creation of quantum physics and the development on its basis of a quantum methodology, is a great event. It has led not only to one element of the triad. Only "the quantum mentality" has created a conceptual framework for considering the physics of the being as an entity.

The next important problem is the future of physics. Now the PIN formulated above fully corresponds to Newtonian paradigm. So any further qualitative development of physics is impossible on this basis. Such is the opinion of many physicists. We occasionally hear an objection to that. Some say there have been predictions of this

kind before, for example, at the end of the nineteenth century. But now the situation is entirely different. The elements of the fundamental triad which form a concrete PIN, that is the relativistic classical physics, the quantum physics and the statistical physics are described (from the point of view of the catastrophes theory) with mathematical structures which are stable in respect to small deformations.

In this sense, the non-relativistic mechanics, the classical mechanics and the phenomenomogical thermodynamics are all degenerate structures, allowing non-equivalent deformations and therefore not stable. At the same time, theories of modern physics are stable theories which cannot be deformed, if we remain within Newtonian paradigm.

The above arguments mean that in the nearest future we shall see not the end of physics but only its end within Newtonian paradigm. Thus, physics is facing a qualitative change of a very grand scale. We may call it a superrevolution. It is connected with a transition from Newtonian paradigm to a new fundamental paradigm which is analogous to Darwinian paradigm in biology. Such a transition corresponds to a change of the most traditional notion of physics. As a result, physics will acquire a new quality and will really become the foundation of all natural sciences. That will be Aristotelian PHYSICS in capitals.

In the new paradigm, the roles of micro and macro descriptions of nature should change places. The notion of a physical quantity, measured experimentally, will remain. However, its importance will not be central, because it will depend on the prehistory of the system. The elements of this evolutionary physics can be met today in cosmology, in the physics of dissipative structures and in synergetics. According to I. Prigogine such a transition is a jump from the physics of the being to the physics of the becoming. Today this is a most important conceptual program of the development of modern physics.

6. Physics within Darwinian papadigm will play the role of a generalized theory of evolution, embracing the organic as weel as the inorganic nature. Its notions should be borrowed from the conception of universal evolutionism and from concrete theories of evolution (from biology, for example). These notions should be used for invariant descriptions in natural sciences. The conceptual core of evolutionary physics (in all probability will be like the Darwinian triad formulated anew in the language of physics like this: "variability-heredity-selection".

From this point of view, there should be a gap between the new evolutionary physics and modern physics. But let us go back to the problem of the origin of the fundamental paradigms of Newton and Darwin within the unified conception of Aristotle. Then it will not be difficult to understand that the study of time will be the foundation combining them.

As is known, time remains until now the most obscure physical notion. In quantum physics, it is not even the observable corresponding to an operator. Many modern thinkers are in doubt as to the existence of universal time of nature. The specifical quality of time is apparent in its topological qualities of order (earlier-later) and qualities of flow (past-present-future).

The physical time that is used in a microcosm has only the quality of order. It has the function of an external parameter. Then all processes are reduced to movement, that is to a smooth change of some and the same parameters of state. Here, there is no difference between the past, the present and the future. These distinctions appear as a secondary quality in the macrocosm in connection with the second law of thermodynamics. This is the time as kynesis of Aristotle or geometrized time, the properties of which are like the analogous properties of space.

The inner time (or age) that we have to deal with in reality in a macrocosm, has nothing in common with the time as a parameter. However, in biology and in other theories of evolution, only time as a parameter is used. Up to now we have not been able to formulate a mathematical technique adequately reflecting the property of its flow.

In other words, in natural sciences, there is no constructive notion of time as a metabole of Aristotle.

The statement of a coincidence of the various "arrows of time" in a macrocosm seems very doubtful. Naturally, some of them are connected with a transition to chaos, and others with a transition to higher ordered structures.

The description of the current time-age as a primary fundamental notion is one of the central tasks of future physics. In its physical sense, it should rather remind us of an operator. Its eigenvalues are the possible values of the age of the system and its mean value is the trivial time-parameter. To give to time the status of an operator, a one-dimensional temporal axis may prove insufficient. In connection with this, the research into spaces with multi-dimensional time and with variable topology appears promising. It is only necessary to extraot from them the invariant contents common to any processes of evolution.

It is this inner time-age, that must evidently define the single direction of nature in a microcosm within Darwinian paradigm. Clearing the fundamental sense of time and especially the properties of its flow - such is the way to the cognition of the physical variant of Darwinian paradigm. At the same time, this is the way to merging (in future) Newtonian and Darwinian paradigms into a single superparadigm of Aristotle, based on the universal time of nature.

Received by Publishing Department
on July 8, 1992.