HUMAN AFFAIRS, *6*, 1996, 2, 111–120

CATEGORIES "CONTRADICTION", "PARADOX", AND SCIENTIFIC KNOWLEDGE*

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Some basic contradictions are described in the paper – antinomies, aporias, paradoxes which cannot be reduced to only purely formal-logical contradictions. Therefore, they are also unsolvable by the language of contemporary formal logic. These contradictions reflect by themselves the contradictions of objective reality and thus demand the formation of a new type of logic, as a science about objective forms of progression and development of thinking, which will be able more adequately – and also in harmony with the requirements of formal logic – to express these contradictions.

One of the fundamental problems of the philosophy and methodology of science is the problem of the development of science, especially the problem of the development of scientific theories which is one of the most discussed issues at present. ([17], [19], [22], [27]) There is a generally accepted thesis that scientific theories are historically changing and developing. The issue of the causes of alternating scientific theories, mechanisms of this alternation, causes of revolutions in science and scientific knowledge remains complex and so far questionable and unclarified within the framework of various conceptions of philosophy and methodology of science and scientific knowledge.

We think that for understanding the essence of the development of scientific theories it is necessary in the first place to grasp the essence of the driving components which affect the dynamics of the development of scientific theories. Contradictory statements in scientific theories also belong to such fundamental driving components. As T. Kuhn puts it, "more profound awareness of the anomaly is a prerequisite to all acceptable changes of theory". ([19], 115) Anomaly[1] appears here as a certain contradiction between scientific theory and objective reality. These anomalies – contradic-

* This paper was supported by the Grant agency: grant No. 2/1358/96.

[1] Anomaly emerges in scientific theory as a contradiction, which can be of different character. In principle it is, however, a discrepancy between the objective reality and the scientific theory, which gives a statement on this reality.

tions which emerge as problems of a special kind in scientific knowledge, create the conditions for crises in science as well as of future changes in scientific theories. "In the period of crisis, the number of anomalies grows and incapability of scientists to solve them is associated with the increase in uncertainty and with a decline in the trust in a paradigm. ...The rules of research are less certain, the number of modifications of the theory increases, alternative theories arise." ([27], 185)

Anomalies in scientific theories are concretized into various types of logical contradictions. As the history of science shows, no discipline of scientific exploration of the objective reality was saved from various types of contradictions. We will mention just some of the best known for illustration. The well known paradoxes in mathematics are those of Burali-Forte, Cantor, Russell, Richard, which are closely connected with the evolution of the theory of sets ([1], [11]), in physics and astronomy the paradox of twins, paradox of the clock, paradox of rotating disc, paradox of the speed of ultrasound, Olbers paradox, paradox EPR, of Einstein, Podolsky, Rosen ([23], [25], [26]). We can mention the well known paradox in genetics, "enzyme cannot produce enzyme". ([28]) And a plethora of other paradoxes could also be mentioned from the area of social sciences.

Another type of contradictions are antinomies and aporias. The best known in the history of philosophy are Kant's antinomies of pure reason about the space, time, finiteness and infinity, simplicity and complexity, necessities and freedom and the well known Zeno's aporias.

Many of these contradictions still remain unsolved or the solutions proposed shifted them to another theoretical level.

Naturally, a question arises. What is the cause of the emergence of these contradictions in scientific theories? What types of contradictions are formed? Can these contradictions be removed from scientific theories in any way? We shall try at least to outline some problems, solutions of which are today closely connected with the existing conceptual tools of philosophy, methodology, and the logic of science.

There are different opinions concerning the formation of contradictions in scientific theories. It mainly depends on the understanding of the concept of "contradiction" as well as on the interpretation of various types of contradictions.

For instance, some authors see the cause of the formation of contradictions in the type of the language of scientific theory used, by which they primarily understand natural language. "Natural language does not enable differentiation either of the predicates of different stages or of linguistic and metalinguistic expressions. This is why it does not provide any protection against various kinds of paradoxes, introducing controversy into the linguistic system." ([2], 11) According to this approach we can avoid contradictions in scientific theories if we use unambiguous, precise logical and mathematical languages which have their semantic and syntactic advantages over the natural language. Contradictions always result from the fact that we do not differentiate between the language of scientific theory and the language we use when speaking about this scientific theory. The cause of the emer-

gence of contradictions in scientific theory is thus non-critical use and non-differentiation of theoretical and metatheoretical concepts or concepts insufficiently (not clearly) defined. As H.B. Curry says, it also concerns logic since contradictions in scientific theories show that the formal logic is not suitable at a certain stage of the development of scientific knowledge as a strict criterion of the precision of scientific knowledge. ([6])

On the opposite side there are authors who take contradictions as an organic part of scientific theory. "Contradiction in theoretical determinations of the object – this is mainly the fact which is constantly reproduced by the motion of science and is not denied by a dialectician, metaphysician, materialist, or idealist." ([14], 242) According to these authors "each science, if confronted with a contradiction in determinations of the object, always tries to solve it. Does it not act in such a case according to metaphysics which regards any contradiction in thinking as something inadmissible, something that we have to get rid of at any cost? ([14], 243) Logical contradiction creates in theoretical expression of things a "necessary logical form in which the development of thinking, transformation from the unknown to the known, from the abstract reflection of the object in thinking, to its more and more concrete reflection take place." ([13], 264) We could quote many other authors whose opinions on contradictions in scientific theories move between these two extreme poles. The citations given show that the essential problem in particular conceptions consists in the interpretation of the concept of "contradiction" itself. In this connection we corroborate the Slovak logician P. Cmorej who says that it is just this word that is a "rich source of chaos and confusing misunderstandings." ([5], 1) We shall try to make a certain definition of this concept and to present some opinions of its application.

Contradiction

In the most general sense, contradiction will be understood as an objective relationship among objects, phenomena, processes of objective reality, or thought, which are either mutually exclusive or conditioning. According to V. Filkorn "contradiction is the truth of negation or confirmation and expression of the truth of negation, negation being a moment of contradiction and contradictions being bearers of negation and the innermost moment of the motion of life". ([10], 272)

Contradictions are usually divided into:

– *dialectical contradictions* – these are objective contradictions appearing in the being of the objects of reality themselves,

– *logical contradictions*[2] – as the existence of the mutually exclusive determinations in the theoretical expression of matters or as a unity and accord of the mutually exclusive theoretical expressions of matters.

[2] Logical contradictions are understood in a wider sense than in the formal-logical sense.

We shall not deal with the issue of dialectical contradictions, which has already been described in non-transparent literature in various philosophical systems. We shall direct our attention towards logical contradictions and their essence.

Logical contradictions within such an approach can be divided into two basic groups:

– formal-logical
– dialectical-logical.[3]

Formal-logical contradictions

This contradiction means conjunction of the statement and its negation (A & ~ A). From the formal-logical point of view it holds unambiguously that the statement and its negation cannot be true simultaneously. It follows from the formal-logical law of the conflict "it is not true that A and not A". The application of the law of the conflict makes meaningful communication among people possible. The respect for the formal-logical law of conflict is in scientific theories of great importance since this law secures formal-logical consistency and non-contradiction of the particular system of responses and thus also of the whole scientific theory.[4]

Since contemporary logic and methodology work primarily with formal-logical systems, ways to define the concept "non-contradiction" of these systems exclusively syntactically, i.e. independently of its interpretation, are sought.

Formal-logical non-contradiction of scientific theory is considered to be one of the necessary criteria of scientific thought, but this criterion is not sufficient. Although it secures formal-logical coherence of the theory, it does not secure the adequacy of the reflection of the content of objective reality in particular theoretical responses.

Dialectical-logical contradiction

The situation concerning the problem of dialectical-logical contradictions is more complex and more problematic (but also more dramatic). Today there are several approaches to the interpretation of dialectical-logical contradictions depending on the solution of the relationship between dialectical and formal logic.

There are three basic approaches:

– there is only formal logic,[5] dialectical logic does not exist,

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[3] Many authors rank dialectic-logical contradictions among dialectic contradictions. Such an approach is considered, however, to be problematic since it complicates differentiation between real contradictions of the objective reality (also in thinking) and their logical form. This is why we call them dialectical-logical contradictions in the logical statement.

[4] There are logical systems, which accept the law $(p \,\&\, \sim p) \rightarrow q$ or $p \rightarrow (\sim p \rightarrow q)$. For instance, intuitionistic logic.

[5] Formal logic is today generally understood as the logic, which builds various formalized calculi, languages, suitable for unambiguous and exact description of various scientific systems.

– there are two independent logics:

– formal, studying formal forms of thought,

– dialectical, studying dialectical forms of thought (processuality of thought) and therefore its conceptual equipment is specific and principally different from the conceptual apparatus of the formal logic,

– there is only one logic encompassing the formal logic as its integral part. Within such a system, the conceptual apparatus being developed is able to reflect (describe) adequately the real contradictions of the objective reality and its evolutionary processuality.

The first group of authors, who evaluate scientific theory strictly according to formal-logical principles and laws, eliminate from these theories any contradiction since in terms of this logic it is inadmissible. Each logical contradiction devalues scientific theory.

The second group of authors admit two logics – dialectical and formal, shifting the concept of dialectical-logical contradiction toward dialectical logic since formal logic does not have competent instruments to solve them. Dialectical contradictions of the objective reality, which they do not doubt, have to be examined by a new type of logic built on principles and laws entirely different from those of the formal logic.

The most promising conception for solving the problems of contradictions in scientific theories seems to be the conception of one logic with various internally intertwined substructures where formal logic appears as a certain aspect, one necessary side of such a logic. Within this understanding, formal logic is necessary but not satisfactory for the analysis of the evolution of scientific knowledge since:

"– it studies thinking from the perspective of linguistic objectification,

– examines only the results of human thinking activities fixed in language and does not analyse the logical forms of spiritual production,

– abstracts from the thought object (factual and idealized, from ideal types of objects), which makes up the cognitive sense of the linguistic terms and thus also the objective content of conceptual thought,

– does not investigate special logical forms of the development of thought towards objective truth." ([22], 35-36)

We think therefore that it is necessary to work out a logic as a comprehensive "science that deals with the objective forms of motion and the evolution of thought" ([4], 34), which would be able to analyse all the existing types of contradictions in scientific theories adequately at the contemporary stage of scientific knowledge.[6] Within the framework of this logic, dialectical-logical contradiction oc-

[6] Hegel already started to work out such a logic and this tendency has gradually been emerging in various philosophical currents of the twentieth century. Fierce polemics are being held about the possibilities of constituting such a type of logic. Unfortunately, we do not know yet the way how to construct an integral system of "dialectic" (processual) logic which would also cover formal logic and would be comparable to its system. Moreover, we also lack a wider theoretical synthetic outlook on this problem.

curs as a logical form of the expression (reflection) of real dialectical contradictions of the objective reality and thus also of the process of thought.[7] This logical form finds its specific expression in antinomies, paradoxes and aporias.[8]

Antinomy

Antinomy is a logical contradiction between statements of scientific theory which seem to be equally true for certain reasons. In principle, it concerns "relatively completed constructions of thoughts, which are in a relationship of contradictory incompatibility and therefore the truthfulness of both cannot be equally provable". ([20], 11) According to E. M. Čudinov, it is a "couple of contradictory statements each of which can be proved separately" ([8], 32) within the formal-logical system founded on certain bases, and, within such a system, the whole developed from such a couple forms an unacceptable logical contradiction. P. Cmorej gives a broader definition: "Antinomy is a logical contradiction which can be acquired through intuitively persuasive deduction from intuitively evident premises, namely a contradiction which differs from other contradictions by the fact that by striving to get rid of it, it leads to the reconstruction of a theory, its language or its logic, or, to the creation of a new theory, language or logic." ([5], 6)[9]

We meet the concept of antinomy for instance in the work of I. Kant who, in his "Criticism of pure reason" constructed his known antinomies of pure reason, and tried to reach a correct proof of both parts – thesis and antithesis. We present their formulation for illustration.

1. The world has a beginning in time and is not limited as to space.

The world has no beginning and is not limited as to the space but is infinite in time and space

2. Each compound substance in the world consists of simple parts and only these simple parts or what is composed of them exists everywhere.

No compound thing in the world is composed of simple parts and nothing is simple in it anywhere.

3. Causality according to natural laws is not the only one, from which all phenomena of the world can be inferred. To explain them, causality through freedom also has to be necessarily added.

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[7] In principle, we differentiate the process of thought as an objective natural-historical process from the forms of the logical utterance of the outcomes of this process in the form of certain linguistic theoretical constructions.

[8] In contemporary works we often meet the ambiguous use of these terms or also their mutual identification.

[9] Interestingly, P. Cmorej's definition also mentions formation of a new logic and the language, although it is not clear whether formal or some other.

There is no freedom but everything in the world happens according to natural laws.

4. There is something that belongs to the world, which is as its part or as its cause an entirely necessary being. Nowhere in the world, or outside it, exists the entirely necessary being as its cause. ([16], 285, 286)

As already Kant but especially Hegel pointed out trying to prove thesis and antithesis, such a proof incorporates petitio principii. "Thesis and antithesis and their proofs thus argue contradictorily that the existing boundary has been already overcome that the boundary has the side to which it relates and beyond which one has to go, where, however, such a boundary is formed again, which is not a boundary." ([12], 264). The proofs of Kant's antinomies are considered by Hegel to be apagic and insufficient.

A question arises: Where is the cause of the emergence of antinomies in scientific knowledge? Can antinomies be avoided in scientific theories?

Antinomies arise in the process of knowing the extraordinarily complex regions of objective reality and are one of the ways of reflecting the objective reality within the existing scientific theory. It means that the existing scientific theories are not able to express adequately the existing contradiction and complexity of the material structures and processes through their formal-logical instruments at the particular level of knowledge, which will be reflected in the particular theory by the emergence of antinomy and logical contradiction.

From the point of view of a formal-logical approach antinomy can be expressed by a formula of classical logic ($p \& \sim p$). This expression itself captures only the external aspect – phenomenal form of the given relation and not its essence. "The peculiarity of antinomic contradictions consists mainly in the fact that under certain conditions of knowledge they give a rational sense to an apparently illogical term of the type (S is P and not P), which formal logic does not admit." ([9], 285) Antinomies differ from formal-logical contradictions by pointing to the problematic character of the tasks being solved; thereby, they do not cast doubt on what has already been achieved in the process of knowledge. They point to the formulation of the qualitatively new task which can only be solved by the qualitative reconstruction of the scientific theory (concepts, principles, laws). "Antinomy is an apparent consensus between dialectic and formal contradiction; it has a phenomenal form of the logical conflict p and not p but in its essence it is something entirely different. The conjunction "and" is not a usual conjunction here; negation is not of the character of real extremes but only of formal extremes." ([7], 277) That is why antinomies cannot be simply ranked among formal-logical contradictions.

If antinomies emerge in scientific theories, the conceptual apparatus of formal logic is insufficient for their solution. It is necessary to look for a new theory, which, through new principles, laws, and categories will express real dialectical contradictions more adequately in the corresponding logically non-contradictory

form. Antinomies become the internal sources of further improvement and the development of scientific theory.[10]

Paradoxes

Another type of logical contradictions occurring in scientific theories are paradoxes. As we have already said, it is just this type of logical contradiction that operates today over a rather wide range in scientific theories.

Paradox is usually understood as an "unexpected, unusual, weird argument which either phenomenally or really disagrees with the recognized and generally accepted experience, with the existing conviction or common sense, although it is formally-logically correct". ([18], 431) Paradoxes are such "theoretical constructions in which a logical contradiction is implicitly included into one of the contradictory statements and emerges in the form of the consequence of statements contradicting each other as a result of the analysis of a compound statement on the object of its logical persuasiveness". ([21], 10) In other words, the scientific theory contains paradoxes, "when each of two contradictory statements, or else one single compound statement having the form of an equivalence between two contradictory statements, has been proved within this theory, though the axioms of the theory seem to be true and the rules of inference valid". ([11], 1)

What is the cause of the emergence of paradoxes in scientific theories? Many authors agree that an inadequate, conceptual and categorial apparatus is used within scientific theories for describing a certain part of objective reality. Thus for instance, in arithmetics, according to Rasiowa and Sikorski, "the paradox resulted entirely from the fact that we did not say precisely what notions and *sentences* belong to the arithmetic and what notions and sentences *concern* the arithmetic, examined as a fixed and closed deductive system" ([24], 146) A. Fraenkel and Y. Bar-Hillel are of similar opinion; they say that contradictions of the theoretical arithmetic emerge "mainly in connection with a natural unrestricted use of the notions of cardinal number, ordinal, and Aleph". ([11, 1)

Paradoxes arising in scientific theories show that at a certain stage of development, formal logic does not secure sufficient precision and adequacy of scientific statements.

Paradoxes are within scientific theories principally divided into two types:

– *syntactic or logical* – we can infer them from the known sentences of scientific theory or deduce from axiomatically built up theory (for instance Russell's paradox about the set of all sets

[10] The resolution of antinomies depends on particular properties, conditions and peculiarities of the areas of their emergence. The solution of antinomic contradiction itself can only be regarded as an achievement of a certain relative truth. The knowledge acquired again becomes the germ of new antinomies. This means that antinomies represent a certain phase in the evolution of scientific theory.

– *semantic or metalogical* – are formed in uncontrolled semantic creation of notions. For instance, notions of definability and truthfulness (Ebulid's paradox "lier").

Although paradoxes within scientific theories have so far been solved mainly through the formation of more complex and more perfect formal-logical systems, the real substance of paradoxes has not been thus revealed. The substance and the cause of the crises in scientific theories consist in the fact that "the obsolete methodology and logic face new discoveries of such a type which principally require a radical change in the interpretation of logic and methodology". ([3], 8) The analysis of paradoxes also shows that for understanding of their substance as well as for their resolution, it is necessary, in addition to the improvement of formal-logical instruments, to seek a new more comprehensive logic. Paradoxes, like antinomies are the inner driving force of the evolution of scientific theories.

Aporias

Aporias are a special type of logical contradiction, which the human race has known for more than 2000 years. Aporias are "degenerated forms of contradictions leading to complications and untrue understanding of the object investigated in its replacement by another object closely associated with it, as if the initial object is forgotten". ([21], 11)

Zeno's aporias are among the best known: the racetrack, Achilles and the tortoise, the stadium, and the arrow.

Aporias are challenging for scientific knowledge by the fact that they are closely connected with the problems of knowing the motion, space, time, structure, and building up of systems in the widest sense as well as with the problems of the foundations of science in terms of the history of the formation of starting notions about reality, like "body", "point", "place", "interval", "motion", "measure", "number", "element", "set", "finite", "infinite", etc.

Although many scientific authorities have struggled to find solutions to aporias since ancient times, they still remain a problem from the perspective of logic. As S. Janovskaja says, "the difficulties which were reflected in Zeno's aporias cannot be considered overcome even at present." ([15], 120) This also indicates that it concerns the problems having much deeper substance than just the form of formal-logical contradictions. What logic does enable understanding of their substance and their solution?

These considerations show that antinomies, aporias and paradoxes cannot be reduced to purely formal-logical contradictions. The formal-logical approach reflects their phenomenal, formal, (outer) side but does not define their substance. From this point of view they create a certain integral part of scientific theories and are the inner driving force of their permanent evolution.

We see the starting point for further research into these problems in:

– a deeper and broader and not only logical analysis of logical contradictions in scientific theories,

– in seeking new logic which will be able to express real contradictions of objective reality more adequately by means of its conceptual apparatus and to solve them in accordance with the laws and principles of formal logic,

– leading philosophical-methodological confrontation with the solutions which were found to be inefficient in different philosophical and methodological conceptions of science.

This is, in our opinion a route, which will enable us to better understand the essence of logical contradictions in scientific knowledge and thus also of paradoxes, antinomies, aporias as well as their role in the development of scientific knowledge.

REFERENCES

[1] Balcar, B. – Štěpánek, P. (1986): *Teorie množin.* Praha.

[2] Bek, R.: *Sémantika přesného popisu reality ve fyzikálně technických vědách.* Praha.

[3] Burrova, J. N. (1976): *Paradoksy teorii množestv i dialektika.* Moskva.

[4] Cereteli, S. B. (1971): *Dialektičeskaja logika.* Tbilisi.

[5] Cmorej, P. (1991): *Antinómie, paradoxy a protirečenia.* (Interný materiál FiÚ SAV) Bratislava.

[6] Curry, H. B. (1963): *Foundations of Mathematical Logic.* New York – San Francisco – Toronto – London.

[7] Černík, V. (1986): *Systém kategórií materialistickej dialektiky.* Bratislava.

[8] Čudinov, E. M. (1968): Logičeskie osnovanija problemy beskonečnosti v relativistskoj kosmologii. In: *Ejnštejnovskij sbornik.* Moskva.

[9] (1978): *Dialektika naučnogo poznanija.* Moskva.

[10] Filkorn, V. (1988): Protirečivé systémy. In: *Filozofia,* 43, 3.

[11] Fraenkel, A. A. – Bar-Hillel, Y. (1958): *Foundations of Set Theory.* Amsterdam.

[12] Hegel, G. W. F. (1986): *Logika ako veda I.* Bratislava.

[13] Iljenkov, E. V. (1985): *Dialektika abstraktného a konkrétneho.* Bratislava.

[14] Iljenkov, E. V. (1977): *Dialektická logika.* Bratislava.

[15] Janovskaja, S. (1963): Preodoleny li v sovremennoj nauke trudnosti izvestnye pod nazvaniem "Aporii Zenona"? In: *Problemy logiki.* Moskva.

[16] Kant, I. (1979): *Kritika čistého rozumu.* Bratislava.

[17] Kedrov, B. M. (1980): *Filozofia a veda.* Bratislava.

[18] Kondakov, N. I. (1975): *Logičeskij slovar – spravočnik.* Moskva.

[19] Kuhn, T. (1982): *Štruktúra vedeckých revolúcií.* Bratislava.

[20] Manejev, A. K. (1974): *Filosofskij analiz antinomij nauki.* Minsk.

[21] Manejev, A. K. (1978): *Filosofskij analiz zenonovskix aporij.* Minsk.

[22] (1981): *Metodologické problémy vývinu vedeckých teórií.* Bratislava.

[23] Pišút, J. – Gomolčák, L. – Černý, V. (1983): *Úvod do kvantovej mechaniky.* Bratislava.

[24] Rasiowa, H. – Sikorski, R. (1963): *The Mathematics of Metamathematics.* Warsaw.

[25] Vanýsek, V. (1980): *Základy astronomie a astrofyziky.* Praha.

[26] Votruba, V. (1969): *Základy speciální teorie relativity.* Praha.

[27] Viceník, J. (1988): *Spory o charakter metodológie vied.* Bratislava.

[28] Watson, J. D. (1982): *Molekulární biologie genu.* Praha.