Philosophy of Science in Ukraine: A Personal Story

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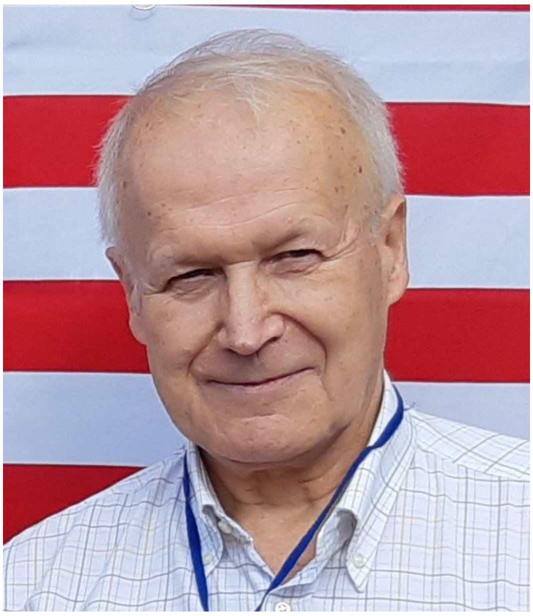

I am a Ukrainian philosopher of physics who worked in central Kyiv not far from where the first bombs fell after the February 2022 Russian invasion. Like many others who are too old to serve, I now live out of the country but remain hopeful of returning to a free and democratic Ukraine.

The borders of the Soviet philosophy of science (Dialectical Materialism or Diamat) were set by the following sacred works: F. Engels's *Anti-Dühring* (*Herrn Eugen Dührings Umwälzung der Wissenschaft* (1878)), *Dialectics of Nature* (1925), and V. Lenin's *Materialism and Empirio-Criticism* (1909). In general, these works offered a mechanistic materialist interpretation of the physical picture of the world of classical physics without considering thermodynamics and electrodynamics.

The history of the philosophy of science in the USSR beginning from the end of the sixties may be considered as the transition from the hard to the soft form of Diamat. It should be noted that other kinds of philosophising about science were practically unknown. Translations of some books by Western scientists and philosophers were published some 10-20 years after their original publications. In many cases, access to them was limited by the sacramental stamp *Only for scientific libraries*. Translations necessarily included extended introductions by editors who rhetorically claimed the superiority of Diamat in solving the problems formulated in these 'foreign' books; tor them, Western scientists could set up philosophical problems, but not resolve them. Access to philosophy of science journals was available only in a few libraries in Moscow and Leningrad. Assuredly, Soviet philosophical society was not open in the Popperian sense.

With the 1991 collapse of the USSR the proclaimed union between scientists and philosophers also dissolved. At present, the Ukrainian state shows no interest in sustaining the philosophy of science (Kuznetsov 2021b) nor any sciences at all (Loktev 2021). The latest publications on the history of Ukrainian philosophy do not mention the works of Ukrainian philosophers of science at all (Tkachuk 2011).

How did I become a philosopher of science?

In 1969 I graduated from the Faculty of Physics of Kyiv University with a specialization in the theory of elementary particles. The curriculum also included the obligatory study of the components of Marxist-Leninist doctrine: dialectical and historical materialism, ethics, aesthetics, the political economy of socialism, the political economy of capitalism, scientific communism, and scientific atheism. In accordance with the Soviet practice of that time, I was recommended for admission to the graduate school of the Institute of Theoretical Physics.

While preparing for the exams, I was unexpectedly called up for two years in the Soviet Army as a lieutenant engineer. The two years I spent in Turkmenistan had a strong influence on my life plans. Fate brought me together with the work of Pavel Kopnin (2022) *Hypothesis and Cognition of Reality* (1962), a book in the library of Krasnovodsk, Turkmen SSR! Another book that encouraged my project was Adolf Grünbaum's *Philosophical Problems of Space and Time* (1963). It stays for me as one of the examples of a serious philosophical and historical analysis of current scientific problems. The idea arose to try my hand at the philosophy of physics and in 1971 I entered graduate studies at the Department of Philosophical Issues of Modern Natural Science at the Institute of Philosophy of the Academy of Sciences of the Ukrainian SSR.

In conditions when the Marxist-Leninist version of the philosophy was considered the only one true philosophy, I presented my thesis about the state of the theory and physics of elementary particles in the categorical language of dialectical materialism. The results were the inclusion in its repertoire categories of interaction, self-development, self-organization, evolution, the world as integrity, actual and potential, observable and unobservable, virtual and hidden types of existence, interaction, nothingness, the Universe as everything, and emptiness (vacuum). Attention was also drawn to the role in physical cognition not of individual categories, but of their compositions. Their examples are bundles of space-time-motion, continuity-discreteness-process, form-matter-interaction, quality-quantity-measure, matter-attribute-form, attribute-property-relation, general-special-particular, and attribute-quantity-value.

The thesis assumed that the transition of physics from conceptualizing knowledge of nature in terms of perceptual constancy, natural place, and natural motion (Aristotelian physics); to various forms of spatial mechanical motion and their causes (classical physics); and now to *causa sui* of the physical world (cosmology) and to the interaction of physical realities as forms of matter differentiation (physics of elementary particles)—has been correctly identified and understood. The universals of physical cognition were analysed in the theoretical context of identifying, individualizing, and differentiating physical realities in terms of their attributes.

Modern scientific ideas about the world, which continue to develop and are unlikely to ever be completed, are fundamentally different from the physical picture of the world of the times of Engels and Lenin. Considering this, for the scientific substantiation of modern philosophical assumptions about categories standing for universal attributes of matter, it is necessary to understand what and how each modern science claims about its field as a part of the material world. Since in modern science it is theories that are the main tool for obtaining new knowledge about the world (experimental data make sense only within the framework of theories), it is necessary to understand how theories fulfil this role. It means that, without a reliable reconstruction of scientific theories as the tools for obtaining new knowledge, an adequate epistemology for the philosophy of science is impossible.

My philosophical position

I recognize the materiality and knowability of the physical world and trust that science gives its sufficiently correct and verifiable picture, which becomes increasingly full and precise. If these provisions are the basic postulates of the materialist philosophy of science, then I am its supporter.

In the last century, the development of experimental studies of the physical/material world has opened realities that could not be described by classical theories. The physical world turned out to be indistinctly split, at least into mega-, macro- and microcosmos. Megacosmos has the Universe as a whole, metagalaxies, galaxies and stars. In the macrocosm there are planets and their satellites, as well as solid bodies, liquids, and gases, without considering their atomic and molecular structure. In the microcosm there are atoms, nuclei, elementary particles, and their constituents.

In other words, each microcosm is "inhabited" by its own autonomous material realities/entities. From an ontological point of view, such realities are the same type of particulars with their inherent attributes. Particulars are individualized by at least one quantitative value of one of their attributes. For example, solid bodies differ in the quantitative values of their mass. All electrons have the same quantitative values of mass, charge, and spin, but in most cases, they are distinguishable by fuzzy values of their energy and spatial localization.

Many contemporary philosophers of science reject these ontological claims. However, productive scientists who understand what and how they work and function as producers of knowledge do not support such a denial. The remoteness of much philosophy of science from the actual practice of science explains why there are so few references of these works in encyclopaedias of science and mathematics.

The centrality of analysis of theories for the epistemology of physics

Trusting what modern science states about the known realities of the Universe and their attributes (see the pictogram *Ends of Evidence*, which shows the spatial dimensions of reliably known realities (Wolchover 2015)), what else is still for the philosophers of science to do in their attempts to comprehend science and its development? To my mind, it is the study of how and by what means physicists and scientists in general make their statements about the Universe, its sub-worlds and their realities.

To reveal this, it is necessary to explain what role theories play in these processes. This is impossible without an adequate understanding of the composition of theories and their relationship to their fields of application. I would suggest that readers, before continuing to look through the rest of this text, fix their answer to the question, what are the components of the theories known to them? After reading this text, I would ask a reader to compare her/his answer with proposed in this article.

Theories are not the pointless speculations of idle minds. Scientific theories have their respective fields of application and produce verifiable claims about those fields. Adherents of Dimat as a theory claim that it has the maximum possible scope. The epistemological problem is that there is no way to test this ontological claim. Representatives of classical physics also claimed the universal applicability of classical theories to describe the physical world and any of its realities/forms of differentiation.

Considering the abovementioned division of the physical world, it is possible, as a first approximation, to distinguish two types of theories. These are the so-called domain-independent theories that describe the universal attributes of different sub-worlds irrespectively of the types of their realities. These are: for the macrocosm – classical mechanics, classical statistical theory, classical thermodynamics, and special relativity; for the megacosmos – the general theory of relativity; for the microcosm – quantum mechanics in its non-relativistic and relativistic versions. In the frames of domain-independent theories, physicists build so-called domain-dependent theories, the domains of which are certain types of realities. Often philosophers of science do not distinguish these theory types.

Philosophically speaking, the domains of domain-dependent theories consist of particulars with their attributes while the domains of domain-independent theories consist of attributes irrespective of the nature of their carriers. Our model connects 1) quantitative values of attributes with the realities in question and 2) operations of both calculating (in theory) and measuring (in experiments) the values of attributes. (Burgin & Kuznetsov 1993b). In what follows, only domain-dependent theories will be considered because their domains include realities while domains of domain-independent theories are abstractions from attributes of the realities in question.

Celestial mechanics is about motions of celestial objects. It describes their space-time trajectories caused be gravity interactions of special bodies – galaxies, stars, planets, their satellites, and comets. The theories of elementary particles are about particles not about macroscopic bodies. The confidence of modern physicists that quarks are components of hadrons is just as grounded as the confidence of the last four centuries' astronomers that the Solar system includes the Sun and planets or the mid-twentieth-century physicists that an atom consists of an electron shell and a nucleus.

Theory and its domain define each other and co-evolute. This does not mean that in the outcome of these processes, the theoretical components become the realities of the theory domain, and the latter transforms into the components of the theory. In the sixties, the domain of the theory of elementary particles included tens of particles. Now, the domain of this theory includes hundreds of newly discovered particles and sub-particles like quarks and gluons. Not going into detail, theoretical components stand for realities while realities are modelled by complexes of theoretical components.

Thus, theory should be analysed in unity with its domain. The latter consists of specific realities of a certain type, their phenomena, processes, and patterns. For example, classical mechanics describes the patterns of motion of macroscopic bodies whose relative velocities are much less than the speed of light. Atomic theory describes the properties and patterns of interaction of atoms at energies that do not destroy atoms. The domain of general quantum theory includes diverse types of microscopic realities, the interactions between which are of a discrete nature. Depending on the type of these realities and the conditions for their experimental study, scientists build corresponding theories of these realities. Such theories form specific networks of interrelated theories. General atomic theory is a net of domain specific atomic theories domains of which consists of various kinds of atoms.

Any real theory is a complex product of, and engine for, the cognitive activity of scientists. Given this, what are the types of components of the theory?

For a long time, the answer offered by the so-called propositional or standard view of theory dominated the philosophy of science (Suppe 1974). According to it, a theory is a static and deductively ordered system of two types of statements related to the realities of its domain. There are several law-like general statements from which an infinite number of singular statements are deduced. This process was understood as theory development. Several derived statements with names of domain realities have empirical content, which makes it possible to compare them with experimental data on realities.

Despite its long life and popularity, the standard view seems too oversimplified to be a relevant view of actual scientific theories, their relationships, and historical development. Practically any set of statements about anything can be called a theory. A vivid example of this is the use of the term *theory* in works of Diamat's gurus.

Joseph Sneed's book *The Logical Structure of Mathematical Physics* (1971) laid the foundation for a structuralist view of theories closer to the actual practice of their use in science. He focused on the representation of realities from the domain of theory through their abstract models, which depict bundles of chosen attributes of realities. Applying the set-theoretic language promoted in the philosophy of science by Patrick Suppes (1957) Sneed, together with Wolfgang Balzer and Carlos Moulines (Balzer et al 1987) formulated and developed the main provisions of the structuralist philosophy of science and used it for studies of theories as systems of models as well as nets of such theories.

Disentanglement of theory into subsystems

Propositional and modelling views do not exhaust theory features/functions in scientific cognition. Indeed, equally important is resolving by theories problems of both intratheoretical difficulties/contradictions and experimental study of the corresponding realities. Theory (scientists who master theory!) stands for realities through their models, so, the abovementioned problems ought to be formulated in the frame of models. As a rule, a theory with a sufficiently large domain deals with many types of problems – general and singular, internal and external, physical and mathematical, fundamental and applied, constructive and analytical, simple and complex, known and new, problems and their subproblems, problems and their superproblems, etc.

One distinctive feature of theory progress is the growing quantity of types of problems formulated in it. These considerations give impetus to the view of theory as a system of problems of various kinds. In contemporary theorized science (Gabovich & Kuznetsov 2019) problems should be resolved within a developing theory by what is available in it and what needs be newly introduced (borrowed from mathematical theories or sometimes specially invented methods). A theory that does not solve problems is useless for scientific knowledge.

Progress in problem solutions is another impact on the development of theory. Every theory has elements in common with other theories and peculiar methods for problem resolution. Classical and quantum mechanics use methods of resolving various differential equations. Methods of the mathematical theory of finite-dimensional geometries are typical for classical mechanics, while those of infinite-dimensional Hilbert spaces are for quantum theory. Therefore, the theory can be also viewed as a system of its methods.

Considering theory as a system of models, as a system of problems, and as a system, in particular, of methods for solving problems, allows us to see that any of these views presupposes and actualizes others. We talked about the chain: models - problems - solutions. Starting from the processes of model construction, we get a more branched nonlinear structure of chains. It reflects the use of languages, methods, approximations, estimates, and heuristics, taking part in model building.

To unite these different views, let us consider theory as a polysystem, the subsystems of which are associated with the mentioned and other views on the theory. Different directions of the modern Western philosophy of science partially and separately studied these subsystems.

We have named this approach the structure-nominative reconstruction of theory. It originated in collaboration with the mathematician Mark Burgin (Burgin & Kuznetsov 1994a; 1994b). Its title is explained by the fact that the components (structures) of the theory are analysed as having definite names in a broad sense. Formal and informal versions of the named set theory (Burgin 2011) supply tools for such an analysis (Burgin & Kuznetsov 1991; 1993a; 1994a).

Informally, the named set is a triple $\mathbf{X} = (X, n, N)$, where X and N are sets from fixed classes, and n — mapping from X in I that belongs to the class M. The set X is called the carrier of the named set $\mathbf{X}$, the set I is the set of names of the named set $\mathbf{X}$, and n is the naming relation of the named set $\mathbf{X}$.

There are individualized, uniquely named, one-named etc. types of named sets.

Take, for example, a triple consisting of the formulations of a certain problem, ways to solve it, and its solution. They are interconnected and create a certain wholeness. This gives the metamodel of this triple a named set. Its carrier is the set of formulations of the problem, the set of names is the set of its solutions, and the naming relation is realized through the set of methods for obtaining solutions.

This is not trivial reformulation because with the help of such metamodeling we can describe in the language of the theory of named sets the interrelated and coordinated changes of sets of: formulations, old and innovative solutions, and traditional and invented methods. Analogous named sets we can construct and study for metamodeling triples of models, modelling relation, and realities modelled; problem solution, estimating relation, and values of estimations, etcetera. In a sense, such metamodeling is like constructing propositions from separate words. It seems plausible to hypothesise that our thinking includes operations not only with words but also with propositions consisting of words.

Thus, the language of named sets can transform the language of the philosophy of science from producing single statements about the corresponding aspects of, for example, realities studied into the language of paragraphs uniting statements in more informative units that describe not separate aspects of realities but their relatively complete picture.

The first version of the structure-nominative reconstruction separates two subsystems roughly corresponding to the standard and structuralist views of theories and established many ties between these views that go beyond logical notions (Burgin & Kuznetsov 1986).

The second distinguishes five inhomogeneous subsystems. Their composition is clear from their titles. These are the logical-linguistic, model-representative, pragmatic-procedural, problem-heuristic, and binding subsystems. The latter fixes the relationship between the components, structures, and subsystems listed above (Burgin & Kuznetsov 1994b).

The third informal version is developing in the collaboration with theoretical physicist Alexander Gabovich. We distinguish ontic, denominative, linguistic, definitional, model-representational, formal-model, logistic, nomic, approximative, problematic, operational, procedural, evaluative, heuristic, hypothetical, and connecting/connective subsystems (Gabovich & Kuznetsov 2019; Kuznetsov 2021a). As shown in case studies of Newtonian mechanics and celestial mechanics, those theories contain all these subsystems. Due to informal character of this version, we prefer to call it as the polysystemic reconstruction of theories (Gabovich, Kuznetsov 2023).

Metaphorically, each subsystem is a specific holographic reproduction of the entire theory. Central to each subsystem are its main components. Its auxiliary components function as *raw materials* for the main ones.

In view of the interweaving of subsystems, when characterizing the components of any of them, it is necessary to refer to the components of other subsystems. For example, building models and posing problems are processes from the operational subsystem. Their implementation requires certain heuristics, estimates, and approximations that constitute the corresponding subsystems of the developing theory. For example, models are helpful for a problematic subsystem, since many of its main components are formulated from the standpoint of modelled realities. In turn, certain problems can be considered as auxiliary to the model subsystem, since they contribute to the analysis of existing models and encourage the construction of new ones. Thus, one can speak about the entanglement of theory subsystems: changes in components of one subsystem produce the proper changes in components of other subsystems.

Problems as components of scientific theory have many aspects. We list only two of them. *First*, problems differ in the situations that led to them. Speaking about the problems of describing, explaining, and predicting phenomena generated by realities from the subject area of the theory, philosophers of science usually do not pay attention to their component composition. If we take them into account, it turns out that these problems are preceded by a range of problems associated with models of realities, with their creation, with the selection and analysis of selected models, with the problems of formulating in terms of selected problem models, with the problems of finding or creating methods for finding solutions to problems, with problems of evaluation of the obtained solutions and problems of correlation of solutions with the data of experimental research of realities Almost each type of the listed problems requires a specific language. *Second*, the problems differ in terms of the characteristics of their formulations. They can be mathematical and physical, internal, and external in relation to the theory, formal and informal, etcetera.

According to polysystem reconstruction, theories can be distinguished by the degree of maturity and development of their subsystems. For example, the model and problematic subsystems of all string theories are currently underdeveloped in terms of their ontic subsystems. The fact is that in terms of the proposed models, problems have not yet been formulated, the solution of which would have consequences that could be evaluated using existing or possible experimental equipment in the near future. The problems that string theorists are currently concerned with are internal to string theories. That is, they relate to problems of development and coordination of its subsystems.

Changes in the components of any subsystem of the theory can give impetus to the development of its other subsystems. Similarly, the emergence of a new theory can begin with the formation of a first and imperfect version of any of its future subsystems. The history of the development of every science is full of examples of such processes. It also opens opportunities to explore diverse types of development of scientific theory, each of which begins with changes in a separate subsystem and, over time, induces changes in other subsystems.

For example, celestial mechanics began with the observations of Tycho Brahe, which Johann Kepler processed. Then the germs of its ontic and denominative subsystems arose. And then came Newton, who introduced all the other sub-systems of celestial mechanics. A polysystemic view of a theory allows us to consider its history as an interweaving of the histories of its subsystems.

Subsystems have a multi-level hierarchical structure. For example, a specific language is a component of a language subsystem. In the first approximation, the language has basic alphabetical, dictionary, phraseological (idiomatic) and text constitutive levels. There are also associated levels corresponding to the actions of building, combining, transforming, and evaluating the components of the language subsystem. These levels include rules and procedures for performing the mentioned actions. Figuratively speaking, the level construction of subsystems is still a true dark matter for most available reconstructions of scientific theories in contemporary Western philosophies of science.

Thus, we can conclude that scientific theories turn out to be much more complex than most philosophers of science think. It is possible that primitive representations of theories are the main reason for the lack of mention of the results of their philosophical analysis both in the sciences themselves, and in didactics and philosophy of teaching science.

In sum, the polysystemic view of theories is characterizes by:

- The natural incorporating and synthesizing various forms (concepts, models, problems, operations, estimations etcetera) of knowledge differentiation into homogeneous subsystems of the scientific knowledge.
- Setting up links between these forms, thanks to which they conjointly contribute to creating new knowledge through changes of available knowledge system.
- Contributing to unification of knowledge systems as each of its separate constituents finds its natural nest with all the necessary links with other constituents.

The polysystemic version of the structure-nominative reconstruction goes further than its first and second versions by:

- Isolating larger number of uniform subsystems.
- Considering both the composition of the subsystems and their transformations.
- Opening prospects for a consistent study of the developments of scientific knowledge systems in terms of changes of its components and their relationships**.**
- Revealing non-trivial relationships between theories

The foregoing account of the structure and analysis of scientific theory has been elaborated elsewhere (Gabovich & Kuznetsov 2023).

Conclusion

There are great distinctions between the views of scientific theory developed by diverse groups of physicists, logicians, philosophers of science, philosophers of science teaching, science teachers, and educators. It is time to work out a single common view based on the analysis of practical theories, and not just what scientists and philosophers of science from different directions say about theories. This requires deepening the nature of science (NOS) studies (see, for example, Badmus & Jita 2022; Erduran & Dagher: 2014; Galili 2019; Khine: 2012; Mathews 2014a, 2014b; McComas 2020; Summers & Abd-El-Khalick 2019; Wallace 2017) to the level of studying the nature of scientific theory (NOST).

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