HYPOTHESES VALIDATION BY DIALECTICAL LAWS

Yuri K. Shestopaloff

Abstract

The article deals with application of philosophical laws of dialectics to verification of non-trivial hypotheses of different kind, as well as considers the process of finding solutions in a broad range of humankind activities using dialectics. As the first phase of verification, the filter that is composed in a certain way from the dialectical laws and categories is proposed, and the whole validation process is described. The dialectical laws should continue to be used in the following more specific stages of research as well, because of their universal nature. The application of dialectical laws is not straightforward in all cases and includes some heuristic component. Even though we define some formal rules implementing such a verification procedure, this consideration remains to be true. We use several specific problems for the demonstration purposes. In particular, we analyze the physical growth mechanism that describes the growth of living organisms from the geometrical and physical perspective. Then, we generalize this growth mechanism and discuss its applicability to different multidisciplinary problems.

Key Words: epistemology, methodology, philosophy, hypotheses, verification, validation.

Introduction

The article's subject relates to philosophy of science, namely to epistemological and methodological aspects of scientific inquiry. The philosophical foundation used in this research broadly can be defined as dialectics. Dialectics first was introduced by Ionian philosopher Anaximander, some information on this account and references can be found in (Shestopaloff, 2008, pp. 25-37). It is possible that some first dialectical envisions belong not only to Anaximander, but Anaximander was the first to formulate several dialectical laws together composing a conceptual foundation of dialectics[1]. We should emphasize the strong purely materialistic nature of Anaximander's dialectics, which is important. In fact, dialectics has been *derived* by Anaximander from the *materialistic* nature of the world.

The next comprehensive research and great advances in dialectical paradigm were made by Hegel in his several works. The major is "Science of Logic". However, unlike Anaximander, Hegel built his version of dialectics essentially on the *idealistic* foundation. His teaching often refers to as *Hegelian dialectics.* The unification of Hegel's dialectics and materialistic understanding of the world created the teaching that is now called dialectics, although sometimes it refers to as "materialistic dialectics". The terminology is still in the development. From our perspective, the term "dialectics"

[1] Some related material can be found in the book by Sir Thomas Heath, "Aristarchus of Samos. The Ancient Copernicus", Dover Publications, 2004, 425 p.

is the most adequate to denote the whole teaching, given the origin of dialectical laws as the most fundamental laws of Nature known to humans that describe the eternal transformation of *matter*. Without matter, dialectical laws cannot exhibit their workings. In case of Hegelian dialectics, this inherent relationship of dialectics and matter has been artificially broken and substituted by idealistic concepts in place of matter. So, if we would like to preserve the integrity of this important scientific discipline, the dialectics, we should incorporate the materialistic foundation as its inherent part *implicitly*, but not explicitly. Otherwise, the materialistic feature will sound as an addition to dialectics, while, in fact, the materialistic nature of dialectics constitutes its essence, its source of origin. On the other hand, we certainly should make such a distinction with regard to other teachings that use apparatus of dialectics as theirs ad hoc feature. This necessary distinction should be done even with regard to Hegelian dialectics, although this can be considered by some people as heresy[2], who came to know this mere discipline as Hegel's creation. However, at present state of science, the materialistic nature of the world is not a hypothesis anymore and hopefully the humankind will not reconsider this intellectual achievement.

In our study, the application of dialectics is restricted by neutral scientific disciplines with well established specific verification practices, including both methodological and experimental approaches. There is a temptation to consider the high level philosophical abstractions when studying the verification from the philosophical perspective. However, any natural phenomenon is a multifactor entity. So, the more meaningful factors we can take into account, and more tools we have (provided we apply them rightly), the more chances are that we preserve the objectivity of our study. An example of such an approach, that proved to be successful, can be found in (Chudinov E., 1977). In this work, the author was able to successfully progress through intricate subject by combining the philosophical perspective with specific validation methods.

Given the epistemological nature of our work and the fact that the area of application is restricted by well established scientific disciplines, we should mention that in some respects the dialectical approach conceptually is close to critical scientific realism (Niiniluoto, 1999).

As it often happens, when some philosophical doctrine is exploited for political or ideological purposes, the scientific content of the philosophical teaching suffers. This is exactly what happened to dialectics. Due to unscrupulous desire to justify some ideological doctrines, the dialectical concepts have been mechanically extended to social phenomena, and in some instances even mangled in order to support subjective inferences. As the result, the dialectics much became associated with ideological teachings. There are many of them, but two major ones are called dialectical materialism and historical materialism. Despite the availability of many valuable scientific achievements in the dialectical materialism, it is often unfairly associated with certain political doctrines. Such attitude undermines the scientific value of this useful analytical and validation tool that includes many valuable dialectical concepts. In fact, the aforementioned political and ideological doctrines originated on the basis of the so called *historical* materialism that pretends to have a dialectical origin. From our

[2] Scientific "quest for truth", as Socrates put it, is unstoppable process. Respect of previous achievements should not become a dogma and obstacle in the following scientific development.

perspective, this is really an ideological doctrine with some interspersed pieces of scientific thinking, which do not add much objectivity to the whole teaching because of the dominance of the precast ideological component.

So, because of some present inconsistencies with regard to the boundaries between the outlined areas, which associate themselves with dialectics, we have to be certain about the apparatus and area of application of dialectics. The clarification of this requirement in itself requires several volumes. In order to preserve scientific quality, we stay away from any ideological content that pretends to be a scientific teaching.

Specifics of verification process

Verification and validation of scientific hypotheses is not a binary problem, but rather we should speak about the *degree* of how we are certain in the validity of some hypothesis, so that the validity fills the whole spectrum of possible outcomes. The transition of some hypothesis to the theory status is a *continuous* process, accompanied by quantitative and qualitative changes and other transformations. The means of validation are usually themselves bear some degree of subjectivity, that should be also counted.

Another important consideration is that the means of verification have to be adequate to the studied phenomenon. Given the fact that natural phenomena are multifactor, it means that the validation approaches also have to account for multifactor nature and provide so to speak the comprehensive "coverage" of all meaningful factors.

The next specifics of real phenomena are their inherently dynamic nature. This can be inferred from our everyday experience and should not encounter the opposition. Everything is changing, all the time. If we consider this issue from the dialectics' perspective, then this inference is a direct consequence of the motion property of matter. For those, unfamiliar with the notion of motion, we will elaborate this thesis as follows. The matter exists only if it manifests itself to other parts and forms of matter. For instance, the stone to be noticed by human has to manifest itself in some form. It can be a visual perception that is provided by quantum of light acting to human's eye receptors. The human can touch the stone by hands, and, based on his previous experience, to determine that he touches a stone. There are numerous ways of interaction of human with the stone. What is common, in all these instances some motion of matter has to occur in order the human will become aware of the stone existence. The other stone can be "aware" of existence of our stone if one stone let us say falls on the other and leaves some marks or changes its position. So, the basic idea is that no motion, no manifestation, no matter. Of course, it is not as simple, but for this article we just need the recognition of the fact that the motion is an inherent (well, actually the *primary*) property of matter. This, in turn, relates to dynamism of all natural phenomena and consequently requires the validation methods to account for this property. The good news is that the validation methods based on dialectics naturally incorporate this feature, that is the ability to incorporate the dynamical nature of reality.

Application of Dialectics' Laws to Scientific problems

The problem of application of philosophical knowledge toward more specific scientific problems is a researched area. There is a generally accepted consensus that it is certainly not only beneficial but even mandatory in many situations for scientists to use philosophical considerations and vice versa. In (Rosenberg A., 2003)) the author says that the philosophy is unavoidable for scientists. The issue is how to correctly apply the philosophy to practical and theoretical problems of science.

We will use the deductive approach in this article. First, we consider particular examples how the dialectics has been used to solve certain scientific problems. Then, using these examples, we provide generalization, and some sort of algorithmization, how to apply the dialectical laws to validate and synthesize scientific hypothesis.

Dialectical laws are applicable to phenomena and problems of *different* scale. However, they are often ignored in hypotheses verification and solution process because of their generality, relative difficulty of perception and lack of education. Let us consider the following example. In experiment, described in (Yu. Shestopalov, et.al. 1980, pp 3-13), there was a situation when the theoretically predicted effect was apparently localized, but its magnitude was compared to the accompanying noise of the experimental electronic system. Existing experimental device exhausted its precision limits. A new more sensitive system had to be designed and implemented. This is the standard technical and engineering solution to this kind of problems the technical team used to. However, the researcher was disappointed by the perspective to spend another three months building a new experimental device and took another approach.

From the high level perspective, which can be viewed as a philosophical, the existing system allowed changing many parameters of the waveguide and electrical parameters of the overall system including the controlling part. In the situations like this, from the dialectical perspective, the *quantity* (the number of independent parameters) is large enough to produce a new *quality*, which means the *possibility* of some qualitatively new solution. So, the dialectical law of transformation of quantity into new quality potentially could be applied in this situation[3]. This was one *philosophical* reason to look for another solution of this seemingly pure technical problem.

However, the interpretation of this law in this particular case is far from straightforward, and we should spend some time in order to at least formulate and maybe elaborate this fundamental problem. This aspect of application of the dialectical law of transformation of quantitative changes into new quality has been also formulated by Alexander Shestopaloff when he reviewed one of the preliminary versions of this work. His consideration is the following. Previously, the transformation of quantitative changes into qualitative has been considered as a self-propelled development, viewed by some people as almost mechanical and necessarily occurring action. Although such an approach can be true as a zero approximation in many instances, in reality, the action of this dialectical law in not as simple. The point of the transformation that is caused by accumulation of quantitative changes is influenced by many other factors, whose impact may accelerate, or deter, or even prohibit the qualitative transformation. Let us

[3] This dialectical law is conventionally applied to phenomena that have some *increasing* quantitative characteristic. However, the reverse is true. Decreasing of some quantity can eventually bring a new quality. If we begin to remove seeds from the *pile* of seeds, then, eventually, we will get just several seeds, and the previous quality, the pile, will disappear. This note has been made by Alexander Shestopaloff from University of Toronto, Statistics Department, during the discussion of the article's material.

consider such a real example. Experimenter-physicist conducted enormous amount of experimental observations with laser technology studying non-linear effects in optics, but was unable to find the general mechanism responsible for the discovered effects. On the other hand, his colleague independently made far less experimental observations but was able to formulate the general hypothesis that later turned out to be true, thus advancing the knowledge to a new qualitative phase. What made the difference, was the ability to *synthesize* new knowledge based on some quantity of facts. Although the number of experimental observations was of the order of magnitude less in the second case, the concentrated and well organized efforts, maybe training, experience, and certainly intelligence have made these qualitative changes to happen.

In fact, the author thinks that Alexander Shestopaloff raised very important and practical issue formulating the idea of "catalytic" factors appending the workings of dialectical laws in general. Going back to our practical problem, we can clearly see this issue. The large number of controlling and signal parameters would not create a new quality, the new data processing method, automatically. What actually advanced the study, was the recognition of the fact that such a transformation in this particular situation is possible, which in itself is important but does not guarantee the success. Next consideration greatly contributing to the success was the localization of the problem domain. The researcher has had to search for a new data processing method, because this is where the quantitative changes accumulated. However, the problem domain should not be restricted by existing parameters only, because this would mean the artificial narrowing of the problem domain, while we know already that the best results can be achieved when we consider the whole entity. So, the option of acquisition of new parameters remained, which meant some possible partial system's improvement. (In general, narrowing down the problem domain and decreasing the generality is a very delicate action that should be done weighting all meaningful factors.) So, this was one reason to widen the problem domain, which also localized the area where the possible solution resides.

The other reason is also of common significance although it is more subtle and much less elaborated in dialectics. In fact, this is the original contribution that first has been described in (Shestopaloff, 2008, pp 37-58), with some applications to biological modeling in (Shestopaloff, 2010). In mathematical physics, there is a notion of "boundary solution", which is the solution belonging to the boundary domain. Certainly, it is not a simple question to answer, if the solution resides in the boundary domain. However, in many scenarios, it is possible to say that *most likely* the optimal solution will not be in the boundary domain (we should not forget that we may have multiple solutions). This is especially true when we deal with a multidimensional problem with loosely correlated parameters, which was exactly the case of the considered problem. In more general philosophical terms, this consideration can be described by the categories of measure and boundary. The aforementioned purely engineering solution to build the new experimental device belongs to the *boundary* of the solution domain, because it does not take into account many other factors. The inability of this solution to do this upsets the category *measure*. If we merge all these considerations, we would come to the inference that beside the purely engineering solution there should be at least one more *inside* the problem domain. This was the reason why the attempt was made to find another solution, which was found quickly,

being almost “on the surface”. Certain combinations of controlling parameters and more sophisticated data processing of experimental results solved the problem without building the new experimental system.

So, in this example, we use the dialectic law of transformation of quantity into quality, with some added new developments, that relate to the *process* of transformation of quantitative changes into qualitative ones influenced by catalytic factors; philosophical category of measure and boundary; and the notion that all natural phenomena by their nature are multifactor ones. These multiple factors are not necessarily tightly correlated and, in fact, the norm is that they are not strongly correlated, which substantially increases the appropriate number of degrees of freedom of the overall system.

Next example is based on work (V. Bogorodsky, et. al., 1985, pp. 2385). The essence of the problem was extraction of information from the radar measurements. There are two major mathematical approaches in this area. The first is to use a deterministic model that is described by equations establishing relations between the measurements and unknown parameters. The second can be considered as a statistical approach. In the last case, a certain decision function (statistical tool) provides evaluation of unknown parameters through the statistical model. Both approaches have limitations, but nonetheless they were considered as canonical approaches in this area. The first is plagued by the so called problem of incorrect mathematical solutions. The other one is unable to use the additional, and apparently useful, information to increase the accuracy of interpretation. Both approaches are considered as unrelated, although they are often used to solve the same problem.

In the cited article, it is shown that both approaches are related. Both represent *particular* mathematical methods for solving the more *general* problem of data interpretation, so that both approaches are subsets of a more general method. These two methods used to be considered as something given forever, ultimately shaped and untouchable truths. In reality, they represented a transitional phase toward newer more precise, more general and more stable methods.

The start point to pose the problem of data interpretation in such non conventional manner, as it was done in the cited article, was the following *dialectical* consideration. We increase the number of measurements and accordingly spend more resources to do these measurements, but none of these extra efforts produce really new quality – more precise data interpretation. This represents a discrepancy with the dialectical law of transformation of quantity into new quality, because, at that point, the quantitative threshold where some new quality could appear has been reached. Moreover, we observed the deterioration of the quality of interpretation when the number of independent parameters and accordingly measurements increased for the statistical approach. This situation was well supported by results in different areas – remote sensing, image recognition, etc. So, this was the first incentive to begin suspecting that the culprit is the interpretation method itself.

The second dialectical consideration that we used relates to interrelation of forms of matter within the same phenomenon. We can say that the phenomenon unites different forms of matter under its umbrella. Because of this interrelation and continuity of matter, matter is inexhaustible in a cognitive sense, which means no knowledge can be ultimate and perfect. This also implies that the knowledge that objectively reflects

the phenomenon is also continuous and interrelated. So, the canonical mathematical methods used for the data interpretation are related through the phenomenon itself. Mathematically, the reflection of this relation most likely can be implemented through the more advanced mathematical method of data interpretation that unites both canonical approaches.

There is one more consideration that should be taken into account with regard to all canonical things. Motion of matter, in different forms, and accordingly reflection of this motion by other forms of matter, brings new developments all the time; this is another reason why our knowledge can never be perfect and ultimate, to say, canonical. Whatever we know, at some point new developments (that never stop, it is just a matter of time when they become big enough to be noticed) will reach such a magnitude that will require corrections and additions to our knowledge because of the new situation. This is why there is always room for improvement of our knowledge, and more such "terra incognitos" are created every moment because of the matter motion. Nothing is ultimate including once developed methods, which represent our reflection of the world through a suitable for these purposes material form. For now, we may call this as the dialectical law of motion of matter, or consider the motion as an inherent primary property of matter. In case of the considered problem, new types of remote sensing measurements appeared whose specifics conflicted more and more with the canonical approaches that could not handle well this specifics; in particular, highly correlated but nonetheless informative measurements in the microwave and infrared spectrums.

In our case, both methods do exactly the same task, they are supposed to find the values of the same parameters belonging to the same phenomenon. The methods, if they have some objectivity, represent our reflection of the same *unity*. So, objective methods of data interpretation have to relate to each other through this unity; they have to produce the same results if they are objective. If they do not, this means their imperfection, their inadequate approximation for our interpretation purposes. This consideration cleared the way toward the development of new better methods of data interpretation.

Overall, together these dialectical considerations created the philosophical and, to some extent, the methodological foundation of the aforementioned research and much contributed to its final success. Probably the major contribution, in this particular situation, was the breaking of mental threshold existing in this area for decades, when two existing approaches were considered as canonical mathematical representations of our knowledge. As it turned out, it was not the case, and never could be.

Works (Yu. Shestopalov, 1993, pp 1060-1065), (Yu. Shestopalov, 1989, pp 67-70) present an interesting, from the philosophical perspective, study of fundamental principles of electrodynamics, namely the relationship of polarization properties of electromagnetic waves and their spectrum in their unity – two fundamental properties of electromagnetic vector waves and electromagnetic fields. This is the area related to Lorentz equations, which later has been thought through and generalized by Einstein into a special theory of relativity. This subject is like a tight knot where philosophy, fundamental electrodynamics and information theory meet together. From the dialectical perspective, we should consider knowledge as an adequate reflection of *objective reality* acquired through *practice*, which is another dialectical category. (Practice, in a nutshell, can be described as an interaction with the reality, receiving a

feedback, and thus adjusting and improving the perception of the reality. With this regard, humans are not alone creatures to whom the notion of practice can be applied.)

As a side note, we should say that the workings of the dialectical law of motion of matter, in some instances, result in positive evolutional changes (we assume conventional criteria of positive evolution), while in some not. In fact, the evolutional process, including the knowledge acquisition, can go any way. On a large scale, all directions of development are equally possible, which includes also progressive changes and degradation (certain criteria to be applied to define what is what). However, at any given moment, the continuity of matter motion may give preference to certain directions of development, but not more than that. Otherwise, everything is possible.

In the discussed works, the dialectics provided several useful services. First of all, the dialectical ideas of motion of matter and interrelation of different forms of matter within the same phenomenon have been applied to knowledge development as a specific form of matter reflecting objective reality (if no some material structure that is capable to store, manipulate and apply acquired information, then no knowledge). This allowed overtaking the hypnoses of the previous approaches and attempting to step beyond the threshold of the previously achieved knowledge. Secondly, the dialectical idea of continuity of matter led to the conclusion that the spectrum and polarization characteristics of electromagnetic waves depend on each other because they represent different aspects of the same material phenomenon. Another dialectical consideration that allowed solving more specific problem was the dialectical law of transformation of quantity (the bandwidth of electromagnetic wave) into qualitatively new polarization characteristics. The existence of such new qualitative states has been proved by analyzing the extreme scenarios of ultimately wide and ultimately narrow bandwidths. The principle of continuity coupled with the notions of evolutionary and revolutionary changes (where no reasons for any revolutionary changes of polarization characteristics in our case) suggested that the change of polarization parameters should continuously depend on the electromagnetic spectrum. So, the philosophical considerations *guided* this particular study through all phases.

There are other examples of successful application of philosophical laws and categories to solving of real problems, we just have no room to present them in this work. We did not mention yet very important philosophical categories of form and content and their relationship, which also has been used in the above studies. The categories of measure and boundary are important to define and restrict the problem domain.

It is important to understand the following. The dialectical laws are not like the criminal or many other types of laws devised by humans that can exist separately and independently, even if some of them or their combinations are irrational and contradicting. The dialectical laws represent different aspects of the same entity, matter or Nature, which are synonyms in this context. In some state of matter, some dialectical laws act more prominently than others, but others continue to work at the same time as well. The workings of *all* dialectical laws at any given place at any given time never stops. (We do not restrict the notions of space and time by our conventional understanding but extend this thesis to *all* states and forms of matter, even presently

unknown.) Dialectical laws inherently belong to the same entity, matter, presenting in *all* matter scales. For instance, we percept the wooden plank as a whole, do not we? We do not separate the plank's height, width, thickness, density, structure and host of known to human characteristics from each other. In this case, we are capable to percept the *whole* entity, which is the normal way of perception of *any* Nature phenomena. This is our human restrictiveness that does not allow us to percept many things in a natural way. This is why we have to subdivide, to slice real phenomena into pieces, although the pieces *never* can substitute for the *whole* (Shestopaloff, 2008, Chapter 1).

Dialectical laws constitute an integral system. This system has no excessive things, but it also does not lack any required component. This is a complete and restricted (but not closed) system of laws existing in their mutual integrity, and only in this way. In fact, in theory, the criminal code can be also understood as a whole entity with all its components interrelated and interconnected. Of course, this is not a "yes or no" situation. The interrelation is also a *continuous* property. As an example, we can see more such interrelationships and interdependencies, more overall consistency in the Justinian code than in the previous Byzantine or Roman laws. With this regard, the dialectical laws can serve as an example of integrity, inherently belonging to a unity – Nature (or, which is the same, to matter). We cannot make the criminal code, or any political system as integral as the system of dialectical laws is, but at least it gives the direction in which to move, and an example of such a system. We also consider this system of dialectical laws as a *systemic* view of Nature.

Physical growth mechanism and the growth equation

We decided to consider this example in a separate section because it is different from the previous illustrations of how to use the dialectical laws in specific scientific studies. Unlike the above examples, the physical growth mechanism and the growth equation appeared as the result of *philosophical inquiry*. During the study of dialectical laws the author eventually reached the point when dialectics as the philosophical teaching, in the author's view, began transforming from hypothesis to theory. As we mentioned already, the dialectics is not the algorithmic and formalized teaching at this point, so that every student has to do much himself to learn the dialectics and to make a validation of this teaching.

Before going further, we should introduce the dialectical law of unity and interaction of dialectical opposites. It is commonly is formulated as the law of unity and struggle of dialectical opposites. In fact, the dialectical opposite not only necessarily struggle, but they also cooperate. Let us consider this example. When the city grows increasing its area, the *surface*, its streets, which happens to have the *linear* structure, help the city to grow. However, eventually the linear structure is no longer able to support the city growth, because the city's area grows proportionally to the square of the city's linear size, while streets still grow linearly. (There is a scaling factor, but it does not withstand the quadratic increase of the city's surface anyway). Thus, two previously cooperating dialectical opposites belonging to the same entity, to the city,

and coexisting within this unity, approach to the state of conflict when the linear nature of streets is no longer able to support the quadratic growth of the city's surface. This state of conflict (which is a common phenomenon in Nature), is resolved by the *compartmentalization* of some parts of the previously single entity. This is why the term "interaction" is more appropriate for this dialectical law. The conflict originates because of the difference in the rates of change, not because of the mere existence of the dialectical opposites, as this law is often mechanically interpreted.

Back to the author's learning of dialectics. When the recognition gradually came that the dialectics is a universal cognitive tool that is founded on the objective and most fundamental laws of Nature, the author was looking for more evidence. The logic was as follows. If the dialectics is true, then it should explain the phenomena of the same or similar level of generality. It happens that at that time the author has been reading a book on cells' replication, so he posed the question as follows. The growth is a universal phenomenon. How would the dialectics explain it? The answer came surprisingly quickly. The growth is explained by the unity and interaction of dialectical opposites, which in case of the of cell's growth are the surface and volume. The *volume* interacts with the environment through the *surface*, both properties coexist in a *unity* because both belong to the same entity and depend on each other. However, they grow at different rates. For instance, in case of a three dimensional object that grows proportionally in all directions, the surface increases proportionally to the square of linear size, while the volume increases proportionally to cube of the same linear size. At the beginning, the quadratic parabola is *above* the cubic parabola, and then the cubic parabola overtakes the quadratic. This is the reason why the growth first proceeds and then stops, because volume's functioning is provided through the surface. Eventually, because of the slower growth rate of the surface after some object's size, the surface is no longer able to support the volume growth. This is the basic idea of the physical growth mechanism. Of course, the growth is a complex phenomenon, and many other mechanisms are involved, in particular, very powerful and numerous biochemical processes. However, from the physical and geometrical perspective, the physical growth mechanism is responsible for the growth of all living species. One of the interesting consequences of this physical mechanism is the introduction of *characterization* of geometrical forms that can grow. Based on these inferences, the growth equation has been derived and applied to the study of cells and multicellular organisms. The research presented many proofs of validity of the discovered growth mechanism. The details can be found in (Shestopaloff, 2010) and several periodical publications.

This example is important from the methodological perspective, when the researcher has begun his study from the high level philosophical considerations and eventually obtained a mathematical equation adequately describing the growth phenomena. The same general vision allowed later to make the generalization of the growth equation and introduce hypothesis that it can be applied to other than biological phenomena. In particular, the urban growth can be described by a similar mathematical equation derived from the growth equation.

In technology, development of complex systems is subjected to similar interaction of dialectical opposites. Let us consider a software application. It grows by modules. Each module interacts with other modules. The number of such

communication paths grows much faster than the number of modules. Eventually it will lead to *inevitable* problems of inter-module communication. What we have here, is a developed conflict between the different *rates* of changes of *quantitative* characteristics of different interacting properties of the system, while at the beginning these properties cooperated, and no system could exist without such cooperation. Thus, we can provide the following general definition of the discussed interaction mechanism.

> *In systems or objects, different rates of quantitative changes of functionally meaningful properties lead eventually to conflict state of the system or object. This conflict results in qualitative changes of the overall system or object in such a way that these changes are directed to resolution of the conflict.*

The whole process of both quantitative and qualitative changes is defined by dialectical laws.

There are some specifics in quickly created systems, for instance, in systems created by humans. Let us consider some distinguishing features of humans' creations that make workings of these laws somewhat different. Nature evolutionary, gradually, through selection and adaptation, developed many mechanisms that provide appropriate qualitative changes to cope with *inevitable* and eventually always coming conflict states. Humankind, however, invented many abstract constructs that do not have such first-line protections from destructions or non-desirable changes. This happens for several reasons. For instance, the life span of many such constructs is too short to trigger the natural safeguards and give them time to mature through trial and error selection processes. Artificial abstract constructs *principally* cannot be completely adequate to reality. So, some degree of inadequacy of humans' constructs will always present. This is just a matter of how good the approximation is. However, we know that any phenomenon changes, so that if our construct is static, or does not have enough flexibility to adjust to changes, then the degree of inadequacy will increase, which eventually brings the whole system into conflict state that may not be resolved. So, the conscious efforts to embed this kind of protection from inevitably originating conflict states (which usually means qualitative transformation of the system or evolving object) should be considered as mandatory for any evolving system, either technological, or social or political in order to keep it at least alive.

Conflict states and their relation to other dialectical laws

In this short section, we explore relationships of the introduced above conflict state to other dialectical laws using few examples. Consideration of relationships with other dialectical laws and categories can be done similar.

Transformation of quantitative changes into qualitative. Conflicting properties experience quantitative changes, which eventually leads to qualitative change of the overall system – we discussed this already. However, there is a second layer of quantitative changes that are meaningful to the following evolvement of conflict and its resolution. This also provides the way toward numerical quantitative measurement of the conflict.

Schematically, it is demonstrated in Fig. 1. Suppose, quantitative changes of each of the property participating in the conflict of a system are measured by values *A* and *B* accordingly. Certainly, we assume that these properties belong to the same entity, exist in their *unity*, so that they can interact. Let us consider sequence of numbers $R_1 = A_1 / B_1$, $R_2 = A_2 / B_2$, … $R_n = A_n / B_n$. Then, the new value $Q_n = R_n / R_1$ is a relative value that does not depend on the units of measure of quantitative characteristics of properties *A* and *B*. Thus, we have a *dimensionless universal numerical parameter* that can be called *growth conflict ratio*. Obviously, this parameter can be calibrated for a particular system based on the known states, such as initial and final ones, or states with extreme values of system's characteristics, which usually can be relatively easily defined. Also, it might happen in some instances that this parameter is a more meaningful characteristic that preserves approximate numerical values characterizing the critical points of transformation across some class of phenomena. Of course, the threshold values of this growth conflict ratio may fluctuate to some extent, because of dependency on the fluctuations of environmental, object's or system's parameters. However, in general, this might be a useful approach.

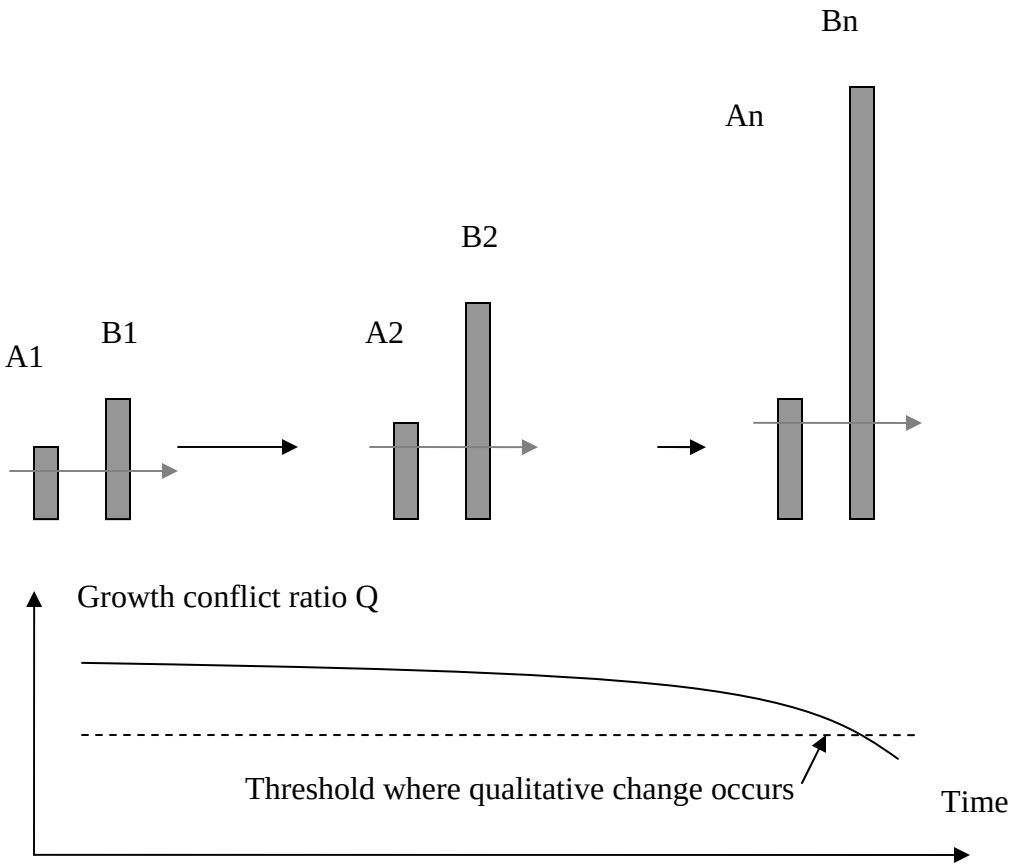

Fig. 1. Accumulation of relative quantitative changes.

Evolution of matter. In case of the biological cell division, we observed how the system evolved into two single cells instead of one during the growth process, in order to resolve the conflict state between the insufficient surface area that can no longer

provide the feeding and removal needs for the growing volume. In this case, we have both evolutional *and* oscillating type of development. Both represent the essence of workings of dialectics laws.

Although the notion of evolutional changes is more or less common, although many variations exist, the notion of *oscillation* nature of natural processes is new. Some original contributions have been made in (Shestopaloff, 2008, Chapter 1) with mathematical illustrations and theorems in the following chapters. The idea of cycles is very popular in many areas of human activities. People like to see the repeating patterns, which idea is very appealing to predictions. We can see this through the whole humankind history and across all disciplines. Maya introduced probably the finest implementation of this cycling idea interposing several cycles together. This, to some extent, contributed to their defeat when Cortez came right in time when two calendar cycles coincided, and this moment was considered in Maya beliefs as a critical point, which was the reason of indecisiveness of Maya's King, how to deal with newcomers. We can see the cycling models in economics, climatology, you name it. In fact, more attentive study that does not disregards the dialectics shows that the cycles are rather exceptions, but even these cycles are never exactly the same, but satisfy to the required degree of approximation. We do not have space to elaborate this concept here, but we the motion of matter does not allow exact cycles, but oscillations that, in some cases, may come close to the starting point. Oscillations represent another fundamental dialectical law. We cannot get rid of oscillation principally, whatever it is. We can reduce them, but we cannot eliminate them entirely. There are several reasons for that, of which two are the motion of matter and infinite number of factors influencing and shaping any natural phenomenon. We cannot control the infinite number of factors, can we? In fact, in our human practice, we really can control even several factors.

Similar, we can consider dialectical categories of form and content, boundary and measure, etc with regard to conflict states and means of conflict resolution. It turned out that in all cases that we analyzed the relationships with dialectical laws are consistent, which gives more credibility to our vision of conflict states as one of the "engine" of eternal changes of matter.

Hypotheses verification by dialectical laws

The inherent unity of dialectical laws, as it was stated above, makes their application convenient and efficient, on one hand. On the other hand, the lack of adequate quantitative apparatus of dialectics makes this procedure more art than science. If we assume that the level of understanding of dialectics is high enough, then, based on presented in this work examples, we can suggest the following methodological approach schematically depicted in Fig. 2. In this figure, we subdivided the hypothesis evolvement into two phases – initial and mature. Based on the above examples and considerations about the universality and omnipresence of dialectical laws, it is suggested to use the dialectic laws through all phases of the research, from the inception and to the very top levels. This means that the same validation approach should continue on the theory level and following after the theory solution level, while each next level of validation propagates its influence through all previous levels. For

instance, the results of solution affect the theory level, as well as the mature and initial hypotheses. We do not show separately *practice* as a validation tool which also presents on all validation levels as a constituent of both specific and dialectical validation methods. We may call, just for convenience, the initial hypothesis as the "seed" hypothesis. Then, the next level can be denoted as the "sprout" hypothesis. Certainly, these notations are subjective, but we found them useful in discussions, because the notions of "seed" and "sprout" bear some qualitative meanings.

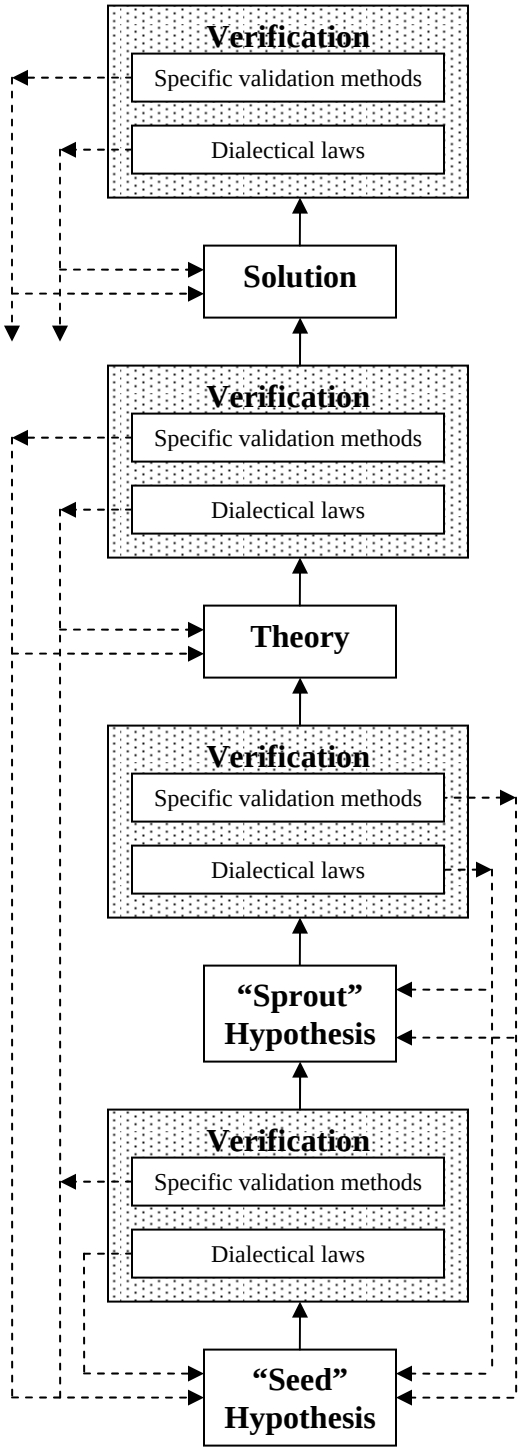

Fig. 2. Validation process for initial hypothesis to promote it to the theory status using dialectical laws and specific validation methods.

Summarizing this approach, we can formulate the first part of a verification algorithm as the direct statement, in the following form.

> *Dialectical laws as means of validation of hypothesis and the tool supporting the synthesis of problem's solution are applicable to all phases of the development, from initial hypothesis to solution.*

The reverse statement is stronger, and it closes (in a mathematical sense) the dialectical verification algorithm.

> *All dialectical laws and categories have to be satisfied on all levels and all phases of research and finding solution of some problem, from the initial hypothesis up to the theory and solution levels.*

It should be understood that the whole premises of this dialectical validation algorithms is based on the assumption that we possess the valid knowledge of dialectical laws. In fact, out knowledge of dialectics is as much restricted by our human nature as any other kind of knowledge. On the other hand, as any other kind of knowledge our understanding of dialectics in some areas is more advanced than in others, so that some dialectical laws and categories can be assigned the status of scientific theory, while others can be considered as hypotheses. For instance, the law of transformation of quantitative changes into new quality, the law of unity and interaction of opposites, the law of negation of negation; the category of measure and many others should be considered as valid and assigned the theory status. Although, of course, new developments can add more details and fine structure to these laws and notions – our knowledge *changes*. This change is a fundamental property of any phenomenon, we discussed this briefly already.

The dialectical laws represent the best knowledge we have today regarding the most general laws governing Nature development. This is their advantage supporting their universality. On the other hand, this universality and generality makes difficult to comprehend and learn dialectics. However, by all measures, the dialectics is invaluable tool for all human affairs. We considered scientific applications. However, other phenomena can be analyzed in the same way using dialectical validation.

The last note in this section that we have to make is this. Often the evolution process is represented as an ascending spiral that never goes downward. To some extent, this is due to Hegel's heritage originated from the idealistic notion of development. In fact, we found more adequate to use another analogy, considering the evolution process as something that endlessly grows like a rose flower, though it does not preserve the initial form of the rose and can transform into different entities. The new petals grow above the older ones from inside. Each petal is a trial, a new direction of development. Petals succeed each other, inheriting the features of the previous petal or a group of petals, adding new features during this process. Many such successions are dead ends. Nonetheless, these trials represent the essence of the adaptation and selection processes, which govern the process of evolution. In the above, the term "evolution" denotes the change, the evolvement of some entity. We disregard the

positive connotation of this term, and give it a neutral meaning, which allows both for the progressive and regressive changes. For instance, this is also the evolutional process if some creatures will not survive. There is no guarantee that an individual, or the whole nation, or even the whole humankind will not end up in one of the numerous evolutional “dead ends”, and never leave it. Dialectical development can go any way. Dialectical processes (which are all natural processes) are defined by many factors. They always have some deterministic component and some random component, whose apportions can vary depending on the situation, but both always present. Nature does not know such things as “good” or “bad”, progressive or destructive. Natural processes just go the way they go. The only restriction is that this motion is performed according to laws of Nature. Other than that, everything else is possible.

Conclusion

Systematic, methodologically correct application of philosophical laws, in particular the dialectical laws and categories, is very beneficial in the process of verification and finding solutions for scientific, technical problems, as well as in other domains of humankind activity. In this work, we analyzed both the methodological and epistemological application of dialectical laws and categories using examples of different generality. Simultaneous usage of dialectical and scientific approaches for solving practical problems is presently based on intuition, common sense and *feeling* of dialectics and its categories. Some of the reasons explaining this situation are lack of philosophical education, difficulty in understanding too general for unprepared people philosophical principles, lots of contradictions between numerous philosophical schools and teachings.

The most straightforward way of introducing philosophical knowledge to everyday level is to make the knowledge itself more adequate, better structured and logically non-conflicting. Next phase would be an introduction of appropriate algorithms that can be applied to real problems. Application of philosophical laws ideally should be done in the same way as now engineers use the most revealing and exotic achievements of physics and quantum theory in their everyday work. On the other hand, the specifics of philosophical knowledge is its comprehensiveness and integrity, which immediately implies that the application of these laws have to be integral as well. It is possible, let us say, to use one dialectical law, such as the transformation of quantitative changes into qualitative. However, the comprehensiveness of the study will be lost. In the same way, an assumption that the growth is a purely biochemical enterprise hurts the objectivity of our knowledge about Nature in general.

As a side effect of our study, we introduced the notions of “growth conflict” and “growth conflict ratio”. The last parameter looks as useful ones for practical purposes, and due to its universality can be applied to a wide variety of phenomena for their quantitative valuation. In the situations where calibration to certain known states is possible, this parameter will have a predictive value. For instance, such a calibration point can be the maximum size of the cell when it switches to replication phase.

The growth conflict mechanism was first introduced implicitly when we considered the growth of living organisms and later generalized for other phenomena, is

also an interesting development and apparently should be regarded as a contribution to dialectics. Should it be considered as a separate dialectical law, or as a consequence of collective workings of other dialectical laws, have to be yet decided. However, its discovery brings new quality to our knowledge about the laws governing Nature evolvement.

REFERENCES

1. Bogorodsky V.V., Kozlov A.I., Shestopalov Yu.K. (1985) “Regularized solutions of microwave remote sensing problems”, *Journal of Technical Physics. Soviet Physics*. V. 55, No 12, pp 2385-2386.
2. Chudinov E.M., Nature of Scientific Truth. (1977) Moscow, Politizdat, 312 p.
3. Niiniluoto I. (1999) Critical Scientific Realism. Oxford University Press, 341 p.
4. Rosenberg A. (2003) Philosophy of Science. Routledge, Second Edition, 213 p.
5. Shestopaloff Yu. K. (2008) “Sums of exponential functions and their new fundamental properties, with applications to natural phenomena”, AKVY Press, 152 p. ISBN 9780980966718
6. Shestopaloff Yu. K. (2010) “Physics of growth and replication. Physical and geometrical perspectives on living organisms’ development”, AKVY Press, 174 p. ISBN 9780980966756
7. Shestopalov Yu.K., Egorov S.T, Morozov V.F. (1980) “Signal propagation in long lines with variable parameters”. *Problems of Radioelectronics. General Problems of Radioelectronics*, No 1. pp 3-13.
8. Shestopalov Yu. K. (1989) “Multiple incoherent wave scattering from statistically rough surface with large steep roughness”, *Radiotekhnika*, No 4, pp 67-70.
9. Shestopalov Yu. K. (1989) “Polarization properties of broadband microwave signals. Symposium on Remote Sensing of the earth surfaces”, Leningrad, Gidrometeoizdat
10. Shestopalov Yu. K. (1993) “Statistical processing of passive microwave data”, *IEEE Transactions on Geoscience and Remote Sensing*, No 5. pp 1060 –1065.

11. Troitsky V.I., Shestopalov Yu. K. (1992) “Utilization of vector radiothermal fields to solve remote sensing problems and process microwave images”, *17-th International Symposium on Photogrammetry and Remote Sensing*, Washington, USA