Ontological Prerequisites for the Emergence of Scientific Cosmology in the Context of the Emergence and Development of the Scientific Thinking

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The article argues that scientific cosmology, the study of the Universe's origin, evolution, and structure, remains an essential and integral part of scientific thinking. The article traces the roots of scientific thinking back to ancient Greek philosophy, particularly the work of Plato and Aristotle. These philosophers were the first to provide a clear justification for scientific knowledge, laying the foundation for its development in subsequent centuries. However, modern science no longer accepts their justifications as definitive. This raises the question: how can scientific thinking function without the traditional foundations laid by the Greeks? The article proposes a solution: general concepts can objectively exist as a property of the inherent uniformity and isotropy of space and time. This is not *limited to just geometric and physical forms but extends to social, cultural, and other realms. Space can be understood as having dimensions, sets of characteristics used to define an object. These "spaces" are abstract constructs humans create to solve specific problems. The same object can occupy homogenous or heterogeneous spaces, depending on the problem being tackled. Time, unlike space, is irreversible and intrinsically anisotropic. However, it can be considered quasi-isotropic and quasi-homogeneous in some specific cases. The development of these concepts of homogeneity and heterogeneity in both physical (geometric) space and time constitutes the foundation of scientific cosmology.*

Keywords: cosmology, logic, scientific thinking, the general, the particular, sphericity, existence, homogeneity, space, time.

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Introduction

Modern cosmology is perhaps one of the most significant and foundational scientific disciplines. In terms of its potential to shape our worldview, it is inseparable from science itself. In a sense, it is the very embodiment of scientific knowledge, as it provides us with a comprehensive understanding of the Universe as a whole. Inherently, modern scientific cosmology concentrates on all the features of science and the scientific way of thinking. It can be considered a kind of "exemplary model of scientificity" on the one hand, and on the other hand, it can be used to study the general laws of the development of scientific knowledge. This is the focus of this work.

A special way of thinking – scientific thinking – is an integral part of science in general or any science, although science is not limited only to the specificity of thinking. Science, although it has existed for a very long time, arises later than civilization itself, which implies the institutions of state and law. However, it is also important to note that science arises not only later but also very locally. The emergence of the scientific way of thinking, and therefore the foundations of science in its modern understanding, we associate primarily with Aristotle, who is considered the "father of science."

Undoubtedly, the set of knowledge that formed the substantive basis of scientific knowledge arose much earlier than the period of classical ancient Greece, and most importantly, this knowledge also appeared in other cultures of the ancient world. This is most clearly manifested in cosmological knowledge, which will be discussed below. However, each of them individually, as well as in total, cannot be considered scientific knowledge. They differ fundamentally from Aristotle's approach, both in terms of content and methodology. Logic is the foundation of the methodology of theoretical scientific knowledge construction. Aristotle explicitly formulated the basis of logic in his "Analytics" (Aristotle, 2009; 2007), which is the only collection of works on logic in the ancient world that explicitly addresses logic issues, with the exception of works written by ancient Indian authors.

In other ancient cultures, too, we can reconstruct the logic of their authors by analysing their texts, at least those that deal with scientific topics. Of course, this requires extensive research, knowledge of multiple ancient languages, and a deep understanding of the cultures in question. These requirements are beyond the scope of this work, which is limited. Therefore, we will refer only to some of the well-known works of ancient authors, which represent the highly developed cultures of the ancient world. The main object of consideration will be astronomical texts and their cosmological interpretation in the context of the stated approach to the methodological identity of cosmology and science. We will also touch on texts in other areas that, in relation to cosmology, act as a methodological tool – mathematics and logic – without which, as scientific knowledge, cosmological knowledge would be impossible.

1. Ancient Chinese and Indian texts on mathematics and logic

One of such works is the ancient Chinese mathematical treatise "The Nine Chapters on the Mathematical Art." It is a classic work that encompasses the knowledge of ancient Chinese mathematicians. It is a loosely coordinated compilation of earlier works by different authors, written from the 10th century BC to the 2nd century BC. It presents a series of problems (246 in total) in a question-and-answer format. A lot of specialized literature has been devoted to its analysis (see, e.g., Dauben, 2013). Of course, within the framework of this work, it is not possible to analyse it in detail as a specific "marker" for the topic of this article. It is worth paying attention to the part of "The Nine Chapters on the Mathematical Art" that is associated with the theorem of the equality of the sum of the squares of the legs to the square of the hypotenuse in a right triangle. In Chinese mathematics, it is called the Gou-Gu theorem, and in European mathematics, it is called the Pythagorean theorem. In European mathematics, this theorem is formulated in general for any values of the legs, and the general theorem is applied to solve the corresponding specific problems. In "The Nine Chapters on the Mathematical Art," the author calculates and proves this statement for the Pythagorean triple of numbers 3, 4, and 5. The authors of this treatise then go on to find other triples of Pythagorean integers by analogy with the first triple, taking it (the first triple) as a model or standard. The example does not capture the heightened level of formal abstract thinking evident in Chinese culture compared to that of ancient Greece. Thus, Joseph W. Dauben points out: "Above all, why did Chinese mathematics develop as it did, as far as it did, but never in the abstract, axiomatic way that it did in Greece?... why the Chinese did not develop a more abstract, deductive sort of mathematics along Greek lines…" (Dauben, 1992: 134). In another passage, he emphasizes: "Compare these developments of the Gou-Gu theorem in the Chinese mathematical tradition with what is to be found in Euclid's Elements. The most striking difference is certainly the axiomatic framework of Euclid's work and its abstract, formal character" (Dauben, 1998: 1341). And further: "It is sometimes asked, why did the Chinese not go on to develop a Euclidean axiomatic mathematics? Why not a more abstract proof, for example, of the Gou-Gu theorem? However, this is surely the wrong question. The real question is why should the Greeks have departed from virtually all other cultures in this respect, namely in their preoccupation with axiomatic, deductive proofs? However, this clearly is a very different problem from determining the origin and nature of Chinese mathematics" (Dauben, 1998: 1346). Thus, we can assert that Greek scientific thinking differs from the types of scientific thinking in other cultures of the ancient world and that this thinking was characterized by a high degree of abstraction and therefore generality.

Continuing this thought, we will now turn to the culture of ancient India. In this culture, like in ancient Greece, logical norms, rules, and principles were explicitly formulated. Driven by the need to defend their views and refute opposing arguments, Indian philosophers engaged in vigorous debates, leading to the blossoming of logic as a discipline. In general, three periods of development of Indian logic can be distinguished in various variations: the first period (early Buddhist logic) – 6th–5th centuries BC – 2nd century AD; the second period (primarily the activity of the Nyaya school) – 3rd–5th centuries; the third period (the flowering of Buddhist logic) – 6th–8th centuries. Indian logic reached its greatest development in the late second and third periods, and the most outstanding personalities of this time were Dignāga and

Dharmakīrti. A complete and in-depth analysis of Indian logic, at least within the framework of this work, is an impossible task due to the volume of the relevant literature and the need to know the original language in which these and other Indian authors wrote (Sanskrit). Therefore, in the context of the problem posed in this article, namely the search for the ontological foundations of the style of thinking that we understand as scientific, we will turn to some experts in Indian logic. Thus, Vincent Eltschinger points out: "Like that of Dignāga, Dharmakīrti's theory is nominalist in the sense that only self-identical and mutually distinct individuals exist. But unlike that of Dignāga, Dharmakīrti's theory provides a causal account of how ultimately erroneous conceptual schemes are linked to the existing world. In other words, Dharmakīrti devised a theory aimed at bridging the gap between a conceptual scheme and the world without being in any way committed to real universals. … §5b. According to Dharmakīrti, ultimate reality is reducible to non-interpreted particulars (svalakṣaṇa). These particulars are momentary (kṣaṇika, see §12b) and owe their transient existence to causal complexes (hetusāmagrī) that entail no relations at all, the mere co-presence of the different factors being enough to account for the rise of an effect" (Eltschinger, 2010: 402). And further, he continues: "§7. The general framework of Dharmakīrti's epistemology is formed by this theory of *apoha* and its account of the Buddhist two truths. This can be seen in the following excerpt (PV 3.1 ac[1] and 2–3): "The means of valid cognition are [only] two [in number, viz. perception and inference], because the [kinds of] objects are [only] two [in number, and this for the following four reasons: first,] because [objects can be either] capable or incapable of causal efficacy; [second,] because [objects can be either] common [to many] or [absolutely] singular; [third,] because [objects can be] referred to by words or not; [fourth,] because the cognition [we have of them] occurs or does not occur when [causal] factors other [than themselves] are present. In the [present system], that which is capable of causal efficacy, [singular, not the object of words and whose cognition does not occur when it itself is lacking] is ultimately real; [as for] the other, [we] declare [it] to be [only] conventionally real. These are [respectively] the particular and the universal." To wit: perception (see §9) alone provides reliable and vivid cognitions regarding individuals, i.e., self-identical and ineffable real entities endowed with functionalities; inference (see §10) is a reliable source of information concerning universals, i.e., pseudo-entities that are causally inefficacious, (apparently) shared by others and verbally expressible. But as Dharmakīrti insists, although these two reliable sources of information may well display two different intentional objects (ālambanaviṣaya), still they bear only upon the real entity (vastuviṣaya) that is their "functional object" (vyāpāraviṣaya), inasmuch as only the real entity is capable of performing a function and hence is of interest to human beings (see §6)" (Eltschinger, 2010: 406).

In turn, Shcherbatskoy F.I. asserts that "Dharmakīrti (NB, 12.13 and NBT, 12.14-15) argues that the senses apprehend the *individual* essence of an object, while thought apprehends the *universal essence*. The individual essence of an object is that which belongs to it alone (sva) and does not belong to *any other* (asādhāraṇa). This is the *true essence* (paramārthasat) of the object, *not imaginary* (anāropita), *not artificial* (akr̥trima) (NBT. 13. 11).

The general essence of an object, which does not belong to that object in particular but to many objects in common, is opposed to it (sādhāranarh rŭpam) (NBT, 14. 8). This general essence of the object is not true, but its *imaginary* (samāropyamāna) (NBT, 14. 6 and 14. 9) essence. As a general and imaginary entity, an object can be known in a clear and distinct representation (avasīyamāno hy arthaḩ), because in this form it is known through the abstract cognition of thought (vikalpavijṇānena) (NBT. 14. 5). The general essence of an object, therefore, is known by thinking, not by the senses" (Shcherbatskoy, 1995: 149). And further: "The general essence of an object is not its true, not its *actual* (arthakriyākāri) form because it is created by thought through the synthesis of individual moments. Through the realization of indivisibility in the chain of moments or through the imaginary unity between successive moments, the imaginary general form of the object is created (see NBTT, 35. 12). Consciousness thus creates a lasting object (sthitam artham santānarŭpeṇa niçcinoti, NBTT, 35. 16) by synthesizing moments. Thinking, which cognizes the general essence of an object, i.e., cognizes it in representation, also has its immediate and final object. But their order is the opposite of that which characterizes sensory perception: it goes from the general to the particular. The immediate object of all thinking is general representation. But since its *function* (pravr̥tti, vyapārā, NBT. 12. 21) consists in the attribution of a general representation to a singular object, then the final result of the thinking process, as understood by Dharmattara, will always be the assimilation in consciousness of the imaginary, i.e., a non-real general representation constructed by the imagination, as one that possesses its singular essence (svalakṣaṇatvena). Thus, the *unreal object* (anarthaḥ), i.e., the representation, which is the immediate *object* of thought, is *cognized* by us *as real* (arthādhyavasāyena). This is the order of action (pravr̥tti) of thought" (Shcherbatskoy, 1995: 152).

Of course, we can get more opinions from experts. However, the above quotations already make it clear that the specificity of Indian logic, in its most developed forms, lies in the fact that it denies the objective existence of the universal as an ontological foundation. According to the above quotations, only the particular and even the individual, has true existence, true being, while the universal is a logical construct that has no ontological significance. From this point of view, Indian logic is a logic of the particular. Therefore, we can formulate the hypothesis that the recognition of the objective existence of the general, universal, and abstract is a characteristic feature of the scientific way of thinking. The appearance of this style of thought, together with specific, rigorous, and systematic knowledge, means the emergence of science as such. We can test this hypothesis on cosmological knowledge.

2. Astronomical texts of ancient Mesopotamia

The substantive origins of astronomy, and on its basis, cosmology as a science, lie in the culture of ancient Mesopotamia. Bartel L. van der Waerden's work "Awakening Science II. The Birth of astronomy" is considered a classic analysis of astronomical knowledge in ancient Mesopotamia. The oldest texts we have come down to with astronomical and astrological content date back to the Old Babylonian period (23rd – 17th centuries BC). The beginnings of scientific astronomy, as a systematic description of the Universe, probably date back to the second half of the second millennium BC. Van der Waerden associates its appearance with three texts written in the Akkadian-Sumerian dialect:

1. The Hilprecht HS 229 text from Nippur.
2. Star lists from Elam, Akkad, and Amurru.
3. So-called "astrolabes" are lists of 36 "stars" associated with the 12 months of the year (Van der Waerden, 1974).

The original Assyrian title of the text is "Three Stars Each." More information about these texts can be found in the above-mentioned work by van der Waerden. The third text is the most important from the perspective of the topic being discussed, as it is the latest and therefore demonstrates the level of generalization of astronomical knowledge of this culture. In modern terminology, this text is an incomplete list of planets and a star catalogue with the distribution of stars, grouped into constellations, by sections of the sky. Objects of the sky (stars, groups of stars, and planets) were divided into three groups: objects of Ea, objects of Anu, and objects of Enlil. Objects of Anu were selected from areas adjacent to the equator, objects of Ea from areas south of the equator, and objects of Enlil from areas north of it. The text also contains comments on the relative position of these objects, their sunrises and sunsets, and their significance for agriculture and mythology.

The development of the "star" catalogue "Astrolabe" (also known as "Three Stars in Each") took place in the catalogue "MUL.APIN," which means "Star/The Plough." It is a three-tablet catalogue, one of which is still missing. The contents of this catalogue can be considered a comprehensive collection of astronomical knowledge from this culture. There are seven copies of this catalogue, the oldest of which is dated to around 687 BC. However, we can assume that this copy is a later copy of earlier originals, so it is likely that this text represents the full extent of astronomical knowledge at the beginning of the first millennium BC. The catalogue "MUL.APIN" is based on the catalogue "Astrolabe," but it also differs from it in that "… the rigid scheme of "twelve times three stars" is replaced by two separate lists: on the one hand, a list of the stars of Enlil, Anu, and Ea; on the other hand, a list of heliacal risings" (Van der Waerden, 1974: 71). There are many analytical works on the content of this text, including the work by Van der Waerden. The translation of "MUL.APIN" can also be found in (Hunger & Steele, 2019; Schaefer, 2006; Watson & Horowitz, 2011), other original texts are presented here, for example (Simpson, 2009).

In the context of the question at hand, the important thing is not what is in MUL.APIN, but what is not. MUL.APIN is a catalogue of stars and planets, but it does not provide a picture of the Universe as a whole. Indirectly, including by relying on the text of Hilprecht HS 229 from Nippur, we can judge that the Babylonian astronomers used a "spherical coordinate system." However, they could not or did not want to explicitly formulate the concept of a spherical universe, and therefore of a spherical Earth, from which observations are made. "Spherical coordinates" were used by them as a mathematical technique. The spherical universe model, which was first known to European science from antiquity until the time of Copernicus, was explicitly formed only within the Pythagorean school, possibly under the guidance of the school's own teacher: "[Pythagoras] is said to have been the first to call the heaven "the cosmos" and to have said that the earth is spherical" **(**Diogenes Laërtius 2018: 48–49). It is likely that this Pythagorean model was a summary of the knowledge presented in the MUL.APIN. At least, Greek astronomers were somewhat familiar with the content of Mesopotamian astronomical texts. Evidence of this is the significant coincidence in the names and locations of the Babylonian and Greek constellations. Depending on the interpretation of the translation, out of the 48 classical constellations (from the catalogue of Ptolemy's "Almagest"), known to the Greeks, up to 30 were borrowed from the East (Thompson, 2010).

The culture of ancient Greece, like the Pythagorean theorem and mathematics in general, was able to abstract and generalize astronomical knowledge. The ability to abstract and generalize has been essential for the advancement of science. In this system, the idea of the sphericality of the cosmos (cosmos is a term also introduced by the Pythagorean school, denoting an ordered, harmonized space) occupies a special place. A sphere is an absolutely symmetrical geometric figure; in a certain sense, it is the geometric embodiment of the idea of symmetry. From Pythagorean cosmology to Copernican cosmology, the Universe was identified in its geometric embodiment with a sphere, and all astronomical objects had a spherical shape. With the discovery of Kepler's laws, other conic sections were included in the considerations of astronomical science. However, spherical symmetry served as the fundamental framework for understanding both individual astronomical objects and the cosmos as a whole. This emphasis remained dominant until the 21st century, when certain empirical data, such as observations of the large-scale cosmic microwave background, spurred the development of alternative cosmological models with non-spherical topologies. Among these, toroidal-shaped universes have received particular attention (see, e.g., Aurich R. et al., 2021). Thus, the idea of the sphericity of the world and world objects arose in ancient Greece as a generalization of astronomical data from the cultures of ancient Mesopotamia. This idea was one of the main scientific ideas for understanding the world from the pre-scientific stage of knowledge to the present day. Only recently has scientific thought gone beyond it.

Scientific cosmology is an indispensable part of the scientific method, and cosmological knowledge only earns scientific standing when it conforms to the established methods, approaches, and principles applied to the study of the Universe as a whole. Yet, it is crucial to investigate the underlying logic and ontology of scientific thinking in order to understand how cosmological knowledge transitions from non-scientific to scientific.

3. Ontology of Plato and Aristotle. Aristotle's logic

In all cultures of the ancient world, except for the Indian and Greek, logic as a system of thinking methods was not formulated explicitly. However, the absence of generalizations, whether in relation to the Pythagorean theorem or to the entire system of geometry, or to the world (Universe) as a whole, suggests that the basis of theoretical cognitive activity in non-Greek cultures of the ancient world was the logic of the particular, not the logic of the general. Generality was also likely seen in these cultures as subjective constructs that do not have ontological status and therefore do not attract the attention of researchers. Properly speaking, such an ontological position is based primarily on common sense, it is inherent in everyday thinking, and provides practical activity in everyday life, which is the guarantee of the existence of man and society.

Greek culture and the Greek style of thinking are unique in this sense. A full analysis of them goes far beyond the scope of this work. The question of the genesis of this specificity remains open and requires further serious and in-depth research. In the context of this work, it is possible to focus on two representatives of Greek classical philosophy: Plato and Aristotle. Their contribution to the emergence and development of science and scientific thinking cannot be overstated, with Aristotle often revered as the "father of science." Together, these philosophers established a crucial path for developing a distinct mode of thought. While both Plato and Aristotle believed in universals as expressed in general concepts, they differed in their understanding of their existence. Plato envisioned a realm of perfect, unchanging Forms that existed independently of the physical world. These Forms act as blueprints for things, imbuing them with their essential nature. A table is a table because it participates in the Form of Table. Plato believed that the human soul, or psyche, had pre-existing knowledge of these Forms. After death, the soul briefly returns to the realm of Forms, and reacquires this knowledge before being reincarnated into a new body. However, the primary form of existence for these Forms remains their independent reality beyond the sphere of the fixed stars, where they exist eternally and unchangingly. Aristotle disagrees with Plato's Theory of Forms. By engaging in a critical dialogue with Plato's concept, Aristotle reinterprets it and builds upon it, presenting his own nuanced version. He expounds this idea most comprehensively in "Metaphysics" (Aristotle, 2009), with elements also explored in "Physics" (Aristotle, 1991) and "On the Heavens" (Aristotle, 1922).

Just like Plato, Aristotle holds that universals objectively exist in the form of general, universal concepts. However, unlike Plato, these universals do not exist in and of themselves, in a "separate place" (beyond the sphere of the fixed stars). Their primary form of existence is concrete, individual things that we perceive through our senses. It is the presence of these concepts as an objective given in things that makes these things the things that they are. For Aristotle, the fundamental reality consists of individual objects, which he calls "primary substances" or simply "substances." These exist independently of our minds and are distinct from general concepts, which he refers to as "secondary substances." Each primary substance is composed of two essential aspects: matter, the material it is made of, and form, the unique essence that defines its type and properties. Take, for example, a specific, ordinary wooden pencil. By examining it, we can see that its physical composition consists of wood and graphite, while its shape and design conform to the conceptual definition of a "pencil," which includes all the characteristic features and functions associated with pencils in general.

Aristotle's approach offers powerful opportunities for understanding the world, particularly in the realm of scientific knowledge. It emphasizes the essential link between theoretical and empirical knowledge, laying the foundation for scientific advancements by establishing a rigorous method for developing theoretical knowledge through formal logic. The deductive method is a key element of this logic. It is the main method of scientific theoretical cognition and is one of the main factors in the heuristic potential of science. The emergence of the deductive method and its use marked the beginning of science in the modern sense. The Greeks' pioneering of science in the Ancient World was fundamentally enabled by the presence of such a systematic method of inquiry. This method, lacking in other cultures, limited their ability to achieve comparable levels of scientific generalization.

To illustrate this thought, let us analyse the following example: let us imagine that there is an alive and cheerful Socrates in front of us. Our task is to prove that he will die sooner or later and that he is mortal. It can be done empirically, and it means killing Socrates. However, it is immoral and criminal. It is also possible to watch Socrates for many years and decades until he dies a natural death, but this method is too long. Therefore, the best option is to prove it theoretically. This can be done quickly and without causing any harm to Socrates. Based on the above, it can be assumed that in the context of the culture of ancient China, evidence would sound as follows:

The Emperor, Son of Heaven, King Hui of Zhou, is mortal because he's already died.

Socrates is the son of the stonecutter.

If the "Son of Heaven" dies, then the stonecutter's son will also die.

That means Socrates will die.

This is the classical analogy where the particular properties (Socrates' mortality) are inferred from the particular properties (the mortality of King Hui of Zhou). Similarly, we can talk about logical proof within the framework of Indian logic. For lack of space in this work, we did not consider the structure of logical syllogisms in Indian logic. Here, we only note that, unlike Aristotelian syllogisms, the Indian syllogism has a five-member rather than three-member form. In application to this example, it will be as follows:

Thesis: Socrates is mortal.

Premise: Because he is a human being.

Example: All human beings are mortal, as is Vardhamana Mahavira.

Application: Socrates is a human being.

Conclusion: Therefore, Socrates is mortal.

It is important to note that the conclusion, like the thesis, in Indian logic is of a particular nature, i.e., it refers to a specific case in which Socrates is one of the people, whereas in

Aristotelian formal logic it is of a general nature but refers to a set that consists of one element – Socrates himself.

And finally, Aristotle constructs the following syllogism:

All men are mortal.

Socrates is a man.

Therefore, Socrates is mortal.

At least for people who are familiar with Western culture, Aristotle's method of proof is often seen as the most convincing. This is because it is a classic deductive argument in the form of a syllogism, where all the premises and the conclusion are general statements. Given the specific relevance of the premise to the topic at hand and the fact that the conclusion's truth depends entirely on the premises being true, it becomes crucial to question the justification for the truth of the major premise. The statement that "All people are mortal" cannot be empirically justified because it applies to all people, including those who are dead, alive, and yet to be born. The truth of the statement "All people are mortal" can be questioned. It is at least impossible to prove it with certainty, and therefore the conclusion that "Socrates is mortal" may also be questionable. However, Aristotle's ontological approach provides a solution. If the concept of "human" exists objectively as a real thing, then it includes the property of being mortal. The major premise of the syllogism simply identifies this property as an objective reality. Immortals are not human, and since Socrates is human, he must be mortal.

The given example illustrates the heuristic nature of Aristotle's concept of the objective existence of general, universal concepts and the effectiveness of their use as the basis of scientific thinking. General concepts are used to form statements that link general concepts. These statements are themselves general (affirmative or negative), because the logical subjects in these statements are general, universal, and comprehensive. These statements represent the formulation of general laws (in particular, laws of nature), which is the central objective of scientific exploration. In addition, the presence of general statements allows the use of the deductive method. It is all this that is a specific and unique achievement of the culture of ancient Greece. The genesis of these achievements was a rather complex and lengthy process, the study of which is very interesting, and which culminated in the formulation of general provisions of formal logic by Aristotle. In all other cultures of the Ancient World, such as ancient China, ancient India, ancient Mesopotamia, ancient Egypt, and others, this process did not occur. Given that there are many such cultures, and ancient Greece is only one, we can infer that the logic of the particular, which is characteristic of all other cultures, is a more natural way of thinking than the Aristotelian logic of the general, which is the logic of the scientific way of thinking. The logic of the particular is based on everyday experience and common sense, which tell us that any generalization is always incomplete. There are always exceptions to any generalization, and therefore general statements about large and infinite sets are meaningless because they are always false. We can only make statements about the world in the form of particular judgements. It is possible that the rejection of general judgments in all other ancient cultures, because they were seen as false and meaningless, and the focus on only particular judgements, prevented these cultures from developing the foundations of scientific thinking and thus science itself. The Greeks' unique recognition of the potential for truth in general statements and their subsequent integration into their culture set them apart as pioneers of scientific thought and laid the groundwork for the development of science itself.

4. The existence of the universal through the categories of space and time

The acceptance of this hypothesis raises a natural and fundamental question: how does science work from the perspective of its ontology? This question is prompted by a number of factors. First, common sense about everyday reality has not been disproven. In fact, any generalization is always incomplete, and there are always exceptions to any generalization. Our everyday empirical experience tells us this. From our vantage point in the early 21st century, it's clear that the arguments for the existence of universal concepts put forth by Plato and Aristotle don't remain persuasive anymore. The idea of a separate Platonic world of Forms, sitting beyond the "sphere of fixed stars" as a distinct region, falls apart. This is because the very notion of such a celestial boundary between the physical world we perceive through our senses and the "realm of contemplation" is outdated and inaccurate. Already Aristotle challenged the existence of the world of Forms. You can find his arguments in his "Metaphysics." Aristotle criticized Plato's theory of Forms by developing his own doctrine of matter and form. In this doctrine, general concepts (forms) exist as objective reality. However, today we understand that the nature of concepts is different. They do not exist in things, but in our consciousness. They are generated by consciousness and change with it. Their bearer is not an object but a subject, and they cannot exist outside the subject's consciousness. They are elements of our thinking first and foremost, and they exist as such elements. But in this case, the logic of the general is impossible. Every subject and their consciousness are private, and we return to simple common sense and its logic of the private, within which science is impossible. It is undeniable that science is the most powerful and fundamental force driving the development and structure of modern society. Then effectively utilising it as a tool for solving social problems requires a solid ontological foundation for the existence of general concepts. From the time of Aristotle to the end of the 19th century, during the period of the formation and development of classical science, Aristotle's ontology served as an implicit justification, albeit in a heavily modified and transformed form.

However, science underwent significant transformations in the 20th century. In light of these changes, we can say that the ontological foundations of scientific thought, such as the doctrine of substance and the objective existence of general concepts, no longer work in modern science. Different hypotheses can be put forward about the form in which general concepts exist as objective reality. One of such hypotheses could be the following: general concepts exist objectively as a property of the homogeneity and isotropy of space and time in a broad sense, as a set of objects of one nature. When we talk about geometric space, we are talking about a continuous set of points. When we talk about physical space, we are talking about a set of physical objects. In addition to these, we can talk about social (a set of people in a social sense), cultural (a set of cultural objects and carriers of their meanings), biological (a set of biota), phase sets in physics and mathematics (a set of states of objects), and other spaces. Objects grouped in these spaces have both common and private properties, and common properties or their combinations can be called the properties of homogeneity and isotropy of these spaces. Of course, these spaces are abstract and ideal. We create them to organize and systematize our perception of reality. However, even abstract objects can be either homogeneous and isotropic or heterogeneous and anisotropic. By identifying general concepts with the properties of homogeneity and isotropy of the spaces they belong to, we resolve the difficult problem of how these concepts exist objectively. Homogeneity and isotropy are not absolute properties. They are conventions that depend on the measure, the semantics of the problem, and the number or scale. The same system can be both homogeneous and heterogeneous, depending on the semantics or measure (scale). For example, the Universe, or the cosmos, is heterogeneous on scales from the Solar System to galaxy clusters. On scales of several billion light-years, it is homogeneous. However, according to the multiverse theory (Deutsch, 1998), on scales much larger than the size of our "bubble," our world is significantly heterogeneous. The properties of homogeneity and isotropy are also manifestations of symmetry. Our consciousness perceives symmetry as a measure of the orderliness of space as a set. In this sense, symmetry acts as an ontological category.

To put it simply, the measure or scale of any space as a set is defined by the knowing subject himself, depending on the tasks he is trying to solve and the data he has available. For example, to solve one problem, we might assume that "All people are equal" (social space is homogeneous). This assumption could be a useful starting point for solving a certain problem. In another case, when solving a different problem with different empirical data, we can assert that "All people are different" (social space is heterogeneous). This assertion can serve as the basis for solving a specific problem. In other words, homogeneity and isotropy are not universal properties of objective reality in any space. They are tools that are attached to humans and simplify the solution of problems that arise before humans and society. Accordingly, general concepts and general statements, from which they are built, are also such tools. If existing general concepts and existing general statements are not enough to solve a scientific problem, then we have encountered a non-uniformity of space, a violation of symmetry. So, we need to change the semantics of general concepts, introduce new, more general ones, i.e., move to other "scales," or, in other words, search for a new symmetry. This is approximately how, according to A. Einstein, science develop: "Science concerns the totality of the primary concepts, i.e., concepts directly connected with sense experiences, and theorems connecting them. In its first stage of development, science does not contain anything else. Our everyday thinking is satisfied on the whole with this level. Such a state of affairs cannot, however, satisfy a spirit which is really scientifically minded; because, the totality of concepts and relations obtained in this manner is utterly lacking in logical unity. In order to supplement this deficiency, one invents a system poorer in concepts and relations, a system retaining the primary concepts and relations of the first layer as logically derived concepts and relations. This new secondary system pays for its higher logical unity by having, as its own elementary concepts (concepts of the second layer), only those which are no longer directly connected with complexes of sense experiences. Further striving for logical unity brings us to a tertiary system, still poorer in concepts and relations, for the deduction of the concepts and relations of the secondary (and so indirectly of the primary) layer. Thus, the story goes on until we have arrived at a system of the greatest conceivable unity, and of the greatest poverty of concepts of the logical foundations, which are still compatible with the observation made by our senses" (Einstein, 1936: 352-353).

While we can theoretically assume any space to be non-uniform and direction-dependent, for some situations, it's helpful to simplify things by assuming homogeneity and isotropy. This makes it much easier to understand and analyse. However, it's crucial to remember that all space, by its very nature, exists in multiple dimensions. In a broad sense, the dimension of a space can be understood as some parameters or characteristics of an object, independent or dependent on each other. In a geometric or physical space, these are coordinates; in a phase space, they are state parameters; in a social space, they are characteristics of people and social groups; in a biological space, they are characteristics of biological systems, etc. Objects of reality have many characteristics. This multiplicity allows us to vary these characteristics, constructing corresponding spaces for a certain quantity. These spaces can be truly homogeneous or quasi-homogeneous, and isotropic or quasi-isotropic. This allows us to formulate general, universal laws.

Conclusions

In conclusion, I would like to say a few words about the homogeneity and isotropy of time. In general, we can understand time as an ordered sequence of events that occur in the corresponding spaces. Physical time is a sequence of physical events; social time is a sequence of social events; and so on. Unlike space, time is one-dimensional. Time progresses one-way, from past to future, and this movement cannot be reversed. The past and future are always distinct and unchanging. The irreversibility of time is fundamental. For closed systems, irreversibility is determined by the growth of entropy, i.e., the second law of thermodynamics. For open systems, it is determined by the process of energy dissipation, i.e., the use of energy to maintain and develop the complex organization of the system, which is also irreversible. Thus, time is always anisotropic. Due to the one-dimensional nature of time, unlike space, we have fewer opportunities to vary and construct systems with homogeneous time. The only parameter that allows us to do this is quantitative measurement, i.e., scale. On a certain time scale, for any system, we can neglect the property of anisotropy. This means that this system does not actually change over these time scales. If we also select for it a corresponding homogeneous and isotropic space, then we can speak of the objective existence of general and universal concepts and the laws constructed from them. However, these patterns will only work in certain time scales and certain spaces. Outside of these limits, they will be unproductive. The constructions of space and time scales, in turn, are tied to the subject or to the social group. They change as the subject or social group interacts with reality, when new problems and tasks of this interaction arise. The process of constructing subject spaces and time scales is a dynamic process, and it is this dynamic that can serve as the ontological basis of the modern scientific way of thinking, giving it the features and qualities described in the concept of fallibilism.

Projecting all of the above in terms of scientific cosmology, we can say that the principle of homogeneity is what gives cosmological knowledge its scientific nature and develops it as scientific knowledge. By introducing the world as a spatially homogeneous and isotropic geometric sphere, the scientific foundations for understanding the world as a whole were laid. In ancient scientific cosmology, the spherical Universe of Plato and Aristotle was unchanging over time; that is, it was homogeneous in the temporal dimension. In the cosmology of the modern era, with the rejection of the spherical universe model, the principles of spatial homogeneity and isotropy were preserved. It was also unchanging, i.e., homogeneous in time. The emergence of relativistic cosmology disrupts this trend with respect to time, overcoming the inertia of thought (a well-known fact about “Einstein’s biggest blunder” in the form of the introduction of the lambda term to preserve the stationarity of the Universe). However, this trend persists in relation to space. The principle of spatial homogeneity and isotropy is the main methodological principle of relativistic cosmology. In the subsequent development of scientific cosmological knowledge, limitingly large scales of geometric space are violated in the concept of the quantum birth of the Universe and in the theory of the multiverse. Partial anisotropy is assumed in the above-mentioned model of the toroidal Universe. All these assumptions and suppositions are quite logical. The “narrowing” and “changes” of the scales of spatial and temporal homogeneity give rise to new scientific general concepts describing the Universe and our world, and together with them, new models and new scientific knowledge about it.

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