Section Three

COSMOS AND HISTORY

Sergei Vsekhsvyatskii's Studies on Philosophical Issues of Cosmology and Cosmogony

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Rudenko, Sergii and Yaroslav Sobolievskyi (2022) Sergei Vsekhsvyatskii's Studies on Philosophical Issues of Cosmology and Cosmogony. *Philosophy and Cosmology*, Volume 28, 146-158. https://doi.org/10.29202/phil-cosm/28/12

This paper analyses the methodological ideas of Sergei Vsekhsvyatskii's Studies on Philosophical Issues of Cosmology and Cosmogony. The article examines the background and history of the development of astronomy and cosmology in Ukraine and its gradual transition from a descriptive method to mathematical analysis. The authors have studied the influence of Ukrainian scholars and philosophers on studies in cosmology, astronomy, philosophical issues in cosmology, and computational cosmology. The philosophical understanding of cosmology and cosmogony is always *a search for alternative views on generally accepted ideas, not intending to deny the merits of other sciences but to critically analyse the conclusions of the natural sciences, made based on empirical data and mathematical calculations. The contribution to global knowledge by Ukrainian astronomers, astrophysicists, cosmologists, and other scientists who work on questions about the Universe has been studied. It is indicated in which modern research areas the main contributions were made (dark matter, dark energy, gravitational lensing). These contemporary problems of cosmology go beyond the usual field of understanding of the natural sciences, which actualises the possibility of an interdisciplinary dialogue between physicists and philosophers on the problems of cosmology and cosmogony. Using the example of Sergei Vsekhsvyatskii's works, the authors showed how philosophical analysis can reveal the weaknesses of the methodology and ask key questions to understand the essence of the processes of space. In the 1960s, he investigated the density of space objects to find new ways to solve the cosmogonic processes of the past. However, even today, the density of the Universe raises major questions. Even though science has made a huge leap in half a century, the essence of scientific and philosophical search remains the same.*

Keywords: Sergei Vsekhsvyatskii, cosmogony of the solar system, philosophical issues of cosmogony, history of cosmology, philosophy of cosmology

Received: 2 November 2021 / Accepted: 1 December 2021 / Published: 27 January 2022

Introduction

The history of philosophical cosmology in Ukraine is closely connected with the history of astronomy and physics. Since astronomical observations are among the oldest in the history of science in the territory of modern Ukraine, the facts from observation of celestial bodies have been known since prehistoric times. The inquisitive human mind seeks to answer eternal questions about the structure of the cosmos. In the Middle Ages and modern times, many unique Ukrainian scholars were interested in natural philosophy and cosmology. They wanted to understand the rules and laws of the Universe, for, throughout its long history, humanity developed naïve experiments of observation and natural-philosophical speculation in complex methodological sciences. The history of modern cosmology in Ukraine is determined by a constellation of outstanding physicists, mathematicians, and philosophers who, in an interdisciplinary dialogue, often use methods and theories of other sciences.

This study aims to describe mathematical and computational cosmology in Ukraine in its historical development to indicate the theoretical basis for the emergence of this science and its philosophical understanding. The importance of this research allows not only cosmologists and philosophers but also historians of science to reconsider the contribution of Ukrainian researchers to the development of science, regardless of historical realities. With growing interdisciplinary research, this topic will expand our understanding of the philosophy of science. The conclusions we reached in this article allow us to assert the independent achievements of Ukrainian science, not only in the field of mathematical and computational cosmology, but also in philosophical cosmology as a whole.

Sources and Cultural Background

The history of astronomical observations and cosmological ideas in Ukraine is an interesting topic. Researchers of the leading astronomical observatory of the National Academy of Sciences of Ukraine, Iryna Vavilova and Tetyana Artemenko, in the article "The oldest evidence of astronomical observations in the territory of Ukraine," described some archaeological finds made on the territory of modern Ukraine. They believe that this is evidence of the interest of our ancestors in astronomy. These findings are dated from the Upper and Middle Paleolithic (100–12,000 years BCE) (Petruk, 2014). The emergence of rational astronomical knowledge and the creation of a system of cosmological notions about the starry sky are the consequences of centuries of practical activity of our ancestors. Interest in astronomical phenomena in the territory of Ukraine was manifested in everyday life. For example, in the Middle Ages, ceilings in buildings were often decorated with starry sky images. In Ukrainian ritual songs, the cosmic act of creation sometimes appears as the process of building a church, and the Universe, space like a temple. The worldview of the Slavs was profoundly religious and was defined by Greek Orthodoxy. One of the first Christian descriptions of the world belongs to Cosmas Indicopleustes (Κοσμᾶς Ἰνδικοπλεύστης). In his book *Christian Topography*, he reinforced the idea of a flat Earth. The cosmos was divine, inhabited by angels, and therefore had a meaning hidden from humans. Only an inquisitive mind could unravel it.

In the second half of the 15th century, Kyiv became a scientific centre, producing many translated works on astronomy, medicine, physics, and logic. One of the first to disseminate humanistic ideas in Ukraine was Yurii Drohobych or Yurii Kotermak (1450–1494). Exploring the cosmos, he wrote the first book published by a Ukrainian, and this book was about astronomy. Professor and Rector of Kyiv-Mohyla Academy Innokenty Gizel (1600–1683) taught students the geocentric model of the solar system as well as the heliocentric model, authored by Nicola Copernicus. In the 18th century, one of the earliest books on astronomy was published in Kyiv, Ukraine. Written in Latin and titled *Theses of General Philosophy,* it contained studies in honour of Ivan Mazepa (1639–1709). It was written by Ukrainian philosophers, theologian Theophanes Prokopovich (1675–1736), and his disciples (Petruk, 2014).

Astronomical research in Ukraine began in the 18th century. It is known that the first observatory on the territory of modern Ukraine opened in Lviv in 1771. After some years, other observatories were opened in Kyiv, Kharkiv, Odesa. In 1845, the astronomical observatory of Kyiv University was opened in Kyiv; the first director was Vasyl Fedorovich Fedorov. The observatory of the Lviv Polytechnic Institute was opened at the end of the 19th century, during the Austro-Hungarian Empire, officially called in German *Observatorium der k.k. Technischen Hochschule in Lemberg*. In 1944, at the time of the Soviet Union in Kyiv, the principal astronomical observatory of the National Academy of Sciences of Ukraine opened, after construction was initiated by Alexander Orlov. Listed discovery dates and cities indicate the constancy of interest in astronomical science. Interest in space exploration has been strengthened by a common interest among scientists in the natural sciences. In Ukrainian, the concept of "space" comes from the Greek word "κόσμος," which means both "world" and "Universe." The etymology of the word enables us to understand this concept in Ukrainian philosophy and science. Whereas in English-language philosophy, space is viewed as an empty opportunity, as a length, as a container of objects, for Ukrainian-language philosophy, the cosmos is understood as harmonious, endowed with meaning and unity.

Modern cosmology is a physical science based on the general theory of relativity, astrophysics, elementary particle physics, fields and fundamental interactions. The task of modern cosmology is to explain all the information about the Universe. If this problem belonged to natural philosophy in the past, today cosmology is trying to describe the evolution of space from the Big Bang to the present state. An essential task of philosophical cosmology is to demonstrate the possibility of contemporary philosophy interpreting physical answers to questions about the Universe. Physical cosmology is currently interested in the topic of cosmological models of a homogeneous isotropic Universe, dark matter and dark energy, relic radiation and models of the early Universe, and the structure of the Universe and its elements. Students traditionally study topics such as the Einstein equation for a homogeneous isotropic Universe, the Friedman cosmological model, the cosmological constant, and the de Sitter model. In addition, they are studying alternatives to the Big Bang theory, indicating a retrospective review and the importance of alternative views. Alternatives to traditional theories do not indicate profanation, but the interdisciplinary nature of research.

Vira Sharomova published the book *Ukrainian Physicists and Astronomers* in 2007, in which she collected and systematised information about more than 500 Ukrainian physicists and 100 Ukrainian astronomers. Evaluating the contribution of Ukrainian scientists to world science, the author focuses on both Ukrainian researchers born in Ukraine and researchers of Ukrainian origin. In chronological order, the book presents the discoveries and inventions of Ukrainian scientists. This information can serve as a basis for analysis from a philosophical point of view, the contribution of physicists to physical and philosophical cosmology. A considerable contribution to Ukrainian astronomy was made by such scientists as Ivan Kortazzi (1837–1903), Boris Ostashchenko-Kudryavtsev (1877–1956), Leonid Semenov (1878–1965), Mykhailo Dichenko (1863–1932), Mykola Zimmerman (1890–1942), Hryhorii Levytskyi (1852–1917), Mykola Evdokimov (1868–1941), Pavlo Romanchuk (1921–2008) (Sharomova, 2007).

Ukrainian scientist and astronomer, Doctor of Physical and Mathematical Sciences, Pavlo Romanchuk, developed a method for predicting solar activity. Since 1967, he has been an associate professor in the department of experimental physics, and since 1972, he has been an associate professor in the department of astronomy and director of the astronomical observatory of Taras Shevchenko National University of Kyiv. The Ukrainian scientist researched the activity of the Sun; he developed a method for predicting the essential characteristics of solar activity. The research findings were used for the needs of basic science and the economy.

It is necessary to mention the current educational materials developed by Ukrainian scientists: Yurii Alexandrov, *Basics of relativistic cosmology* and Iryna Vavilova, *The Universe's large-scale structure*. In his book, Yurii Aleksandrov states: "In the last two decades, cosmology began to study processes of the early Universe – with such great values of energy, when it required the application of a theory that describes the Universe as a quantum object and, at the same time, a gravitating object. At the intersection of the cosmology of the early Universe and the physics of ultrahigh energies, we managed to approach the creation of a unified field theory." (Alexandrov, 2001: 20).

Significant contribution in the field of astrophysics did Volodymyr Tsesevich (1907–1983), who studied variable stars for decades, Mikola Barabashov (1894–1971), Ukrainian astronomer, rector of the V. N. Karazin Kharkiv National University, and he made observations of the Moon and planets of the Solar System. In particular, he made a series of observations of Mars in various spectral ranges; based on the data, a map of the planet's surface was compiled, the albedo was calculated, the colour of various sections, the law of reflection and other observations. Together with the Kharkiv Observatory, he took part in processing data from the Luna-3 space program and became one of the authors and editors of the first Atlas of the Far Side of the Moon. "In the second half of the 1920s, the scientific interests of M. P. Barabashov completely focused on the study of physical conditions on the Moon and planets. He became convinced that the Moon and planets as bright objects are quite accessible for research with relatively modest observational means" (Shkuratov, 2008: 85).

The first professional Ukrainian astrophysicist was Alexander Kononovich (1850–1910), who worked as head of the department of astronomy and director of the observatory of Odesa State University. He introduced a course of astrophysics for students and acquired advanced instruments from Europe for the observatory. He studied binary stars, performed photometric studies of planets, the Sun and its activity, and the spots on the surface of the Sun, and devoted his dissertation to the problem of prominences. He graduated many scientists as astronomers, physicists, mathematicians, and cosmologists: Alexander Vasilyev (1868–1947) studied the rotation of Venus, Alexei Gansky (1870–1908) discovered the dependence of the shape of the solar corona on the number of spots, Artemii Orbinsky (1869–1928), and many others (Kolchinsky, 1977). The case of Alexander Kononovich was continued by Alexander Yakovlevich Orlov (1880–1954), who developed astronomy and cosmology. He, in turn, trained a whole generation of astronomers including computer observer, director of the Poltava Observatory, Zinaida Aksentieva (1900–1969), Ivan Dyukov (1888–1961), a researcher of celestial mechanics, Vencheslav Zhardetsky (1896–1962), a native of Odesa, and professor at Harvard University Dmitry Pyaskovsky (1891–1970). Alexander Orlov's interest in questions of the history of science found expression in teaching astronomy and researching the history of the Astronomical Observatory at the University of Kyiv.

Dmitry Pyaskovsky was the first to compile a comprehensive outline of the history of the Kyiv Observatory from its foundation until 1954. In 1834, Kyiv University was founded in Kyiv; it consisted of one faculty, philosophical, but with two departments: humanities and natural sciences (including astronomy). A year later, in 1835, the department of astronomy was founded, the activity of which is connected with the name of the scientist Vasyl Fedorov (1802–1855), professor and rector of the Imperial University of St. Volodymyr. From 1945 until his death, Ukrainian astrophysicist Alexander Bogorodsky (1907−1984) taught astronomy at Kyiv University. He wrote works in the field of the general theory of relativity, astrophysics, and the history of astronomy. The famous scientist Klim Churyumov (1937–2016), a specialist in comet astronomy, the discoverer of two comets, worked at the Kyiv Observatory. He was the corresponding member of the National Academy of Sciences of Ukraine, a full member of the New York Academy of Sciences, and director of the Kyiv Planetarium. One of the comets discovered by him (comet Churyumov-Gerasimenko) was visited by the space probe of the European Space Agency Rosetta. He received higher education at Kyiv University and worked at the Arsenal factory. In 1972, he defended his thesis *Research on the comets of Ikea-Seki (1967n), Honda (1968c), Tahoe-Sato-Kosaka (1969IX) and the new short-period comet Churyumov-Gerasimenko based on photographic observations*. In 1993, at the Space Research Institute of the Russian Academy of Sciences, he defended his doctoral dissertation on the topic of *Evolutionary physical processes in comets*. At the initiative of Klim Churyumov, one small planet was named after the famous Ukrainian philosopher Gregory Skovoroda (Melnyk & Churyumova, 2012).

Klim Churyumov's students and colleagues continue his work. Doctor of Physical and Mathematical Sciences, Professor Valerii Zhdanov, wrote his dissertation *Research on the equations of motion in the relativistic dynamics of interacting particles* (1974), *Methods of approximation and qualitative analysis in relativistic dynamics* (1992), *Introduction to the relativistic theory of attraction* (2004). His research interests include relativistic astrophysics, relativistic astrometry, cosmology, the theory of relativity, and relativistic dynamics. He prepared specialised courses on the general theory of relativity, cosmology, and synergetics in astronomy at the physics department of the Taras Shevchenko National University of Kyiv. Doctor of Physical and Mathematical Sciences, Sergii Parnovskiy, Senior Researcher, Professor, Taras Shevchenko National University of Kyiv, in 1981 he defended his thesis on *Investigation of solutions of gravitational equations with features on temporal hypersurfaces*. In 1993, he defended his doctoral thesis *The behaviour of space-time and non-gravitational fields near clock-like singularities* in the speciality "theoretical physics." His scientific interests embraced the general theory of relativity, relativistic cosmology, astrophysics, and extragalactic astronomy. Ukrainian astrophysicist Bogdan Hnatyk is a doctor of physical and mathematical sciences, professor, director of the astronomical observatory of Taras Shevchenko National University of Kyiv (2001–2004). In 1983, he defended his thesis, *Physics of shock waves and regularities of their motion in the shells of stars,* and his 1997 doctoral thesis, *Non-stationary high-temperature processes and shock waves in space plasma*. Bogdan Hnatyk's field of research is high-energy astrophysics, mechanisms for accelerating ultra-high-energy cosmic rays. He has developed hydrodynamic methods for modelling non-stationary high-temperature processes and dynamics of shock waves in space plasma.

The Ukrainian Astronomical Association (UAA) was founded on January 24, 1991, in Kyiv. In 1992, UAA was admitted to the European Astronomical Society, and since 1993, it has acted as the Ukrainian National Committee of the International Astronomical Union. Today, Ukraine continues to cooperate with foreign companies and research centres in the field of rocket science, the manufacture of spacecraft, and in 1997, by agreement with the US government and NASA, the first and so far the only astronaut of independent Ukraine, Leonid Kadeniuk (1951–2018), flew into space. Astronautics, astronomy, astrophysics, computational, and mathematical cosmology continues to interest Ukrainian scientists, calling for international and interdisciplinary cooperation.

At the end of the last century, revolutionary changes took place in astronomy, the result of which was the introduction to the widespread use of such concepts that until recently could have been considered not physical but metaphysical. It is difficult to imagine how non-baryonic "dark matter" and "dark energy," about the nature of which so little is known, are possible. The name itself does not refer to their black colour, but to our ignorance. The Universe consists of types of matter that practically do not manifest themselves in any way, but for which there are indirect pieces of evidence. We know only a small part of the cosmological density. However, cosmology is now entering a new stage of development associated with close interaction with other branches of knowledge, requiring both high accuracies of observations and the accuracy of theoretical predictions, both the tools of the natural sciences and the ability to work with the paradoxical knowledge of the humanities. It is worth recalling the classic example with the complementarity principle proposed by Danish physicist Niels Bohr and his interpretation of quantum mechanics. It is known that, for a complete description of quantum mechanical objects, two mutually exclusive or complementary classes of concepts are needed, each of which is applicable in special conditions. Their combination is necessary to reproduce the integrity of these objects. The physical meaning of the principle of complementarity is that quantum theory is associated with recognising the limitations of classical physical concepts in relation to atomic and subatomic phenomena. Dark energy (DE) is usually called the reason for accelerated cosmological expansion. The DE mass density is more than 70% of the average mass density of the Universe.

According to modern concepts, DE is evenly distributed in the Universe. From the data on the chemical composition of the Universe, it was found that baryonic matter can be no more than 5% of the total cosmological density. The remaining 25% is unknown non-baryonic invisible dark matter (TM); it does not react with ordinary matter, which makes it elusive. The spatial distribution of dark matter (DM) is concentrated in the vicinity of the galaxies and their clusters. At the beginning of the 21st century, an international programme was carried out in which the Special Astrophysical Observatory in Russia took part, along with the Max Planck Institute, Germany; Hubble Space Telescope Institute, USA; and Astronomical Observatory of the Taras Shevchenko National University of Kyiv, Ukraine. As a result of this cooperation, a thorough analysis of previous observations was carried out, 97% of the entire sky was examined, and a detailed three-dimensional picture of the distribution of local galaxies was built for the first time. Measuring the velocities and distances to galaxies made it possible to determine the content of dark matter in groups of neighbouring galaxies (175 years of the Astronomical Observatory of Kyiv University, 2020).

Cosmologists around the world face the daunting task of trying to uncover mystery and predict the evolution of the Universe from early times to the emergence of galaxies. This is a difficult task for mathematicians since we are discussing calculating the trajectories of billions of interacting DM “particles” together with the distribution of gaseous baryonic matter. This problem is complicated because DM practically does not interact with ordinary baryonic matter and it can be registered only, as stated above, by indirect signs—gravitational action. The force of gravity in DM clots is so great that it affects the movement of stars and entire galaxies, and scientists are already able to track the movement of such large objects through the effects of the gravitational deflection of light. This new direction in astrophysics has received the name gravitational lensing since the essence of the phenomenon is that the action of the gravitational field resembles the action of a conventional optical lens, but only with a very large focal length. The gravitational field, like a lens, deflects light from its path, which allows an observer on Earth to see this distortion. Because astronomical scales are huge, gravitational lenses can amplify the light of distant objects several times, and today, this is one of the most promising methods for studying the spatial distribution of mass in space. Even if TM is invisible, it creates a gravitational field that distorts the image of distant objects and, therefore, in some way, becomes visible. After all, what is essentially vision, is a feeling that also receives information about the external world indirectly through the reflection of light from external bodies. We assert the visibility of an object based on receiving a light signal, while the object itself remains incomprehensible to us. Likewise, when we receive information about TM, we analyse light, not reflected, but distorted, which is not very different. The contribution of Ukrainian astronomers to the development of research methods for gravitational lensing is significant. The world’s first monograph on this effect was published by scientists from Kharkiv Pavlo Blioh, Anatolii Minakov. *Gravitational lenses* (1989), theoretical models, and their interpretations were created, which significantly improve the accuracy of the light curves in gravitational lenses (Zhdanov, 2008).

Philosophical Issues on Cosmogony of Solar Systems

Scientific progress does not stand still. This is a well-known fact, but whether this process is a process of neglecting previous achievements is a key question in the philosophy of natural science. The natural sciences are characterised by emergent leaps in the process of obtaining new empirical knowledge, based on which, new theories are built. Thus, the history of science becomes a complementary analysis of the achievements of previous generations of scientists. However, if we approach the study of the heritage of the natural sciences from the point of view of philosophy, then each era acquires a unique, independent meaning, and each research acquires an end in itself, like an artefact of the past. Just as the philosophy of science studies the ideas of the representatives of natural philosophy of the 18th and 19th centuries, such practices are possible and necessary in the 20th century. The legacy of the past carries with it a unique meaning that is relevant to the present. Nataliia Yarmolitska and Katherine Gan, in their article 'Odesa's research school in Ukrainian philosophy of the Soviet period: historiography and future perspectives' (2020), agree with such ideas: "Studies of the philosophical heritage of the Soviet era, determining its impact on modern domestic cultural practices, are becoming increasingly important. Systematic study and holistic theoretical reconstruction of the scientific view of functioning in the system of science and education of philosophical research of the Soviet period, due to the need to develop new ideological and theoretical foundations for the development of philosophical knowledge, increase the professional level and practical significance of scientific research" (Yarmolitska & Gan, 2020, p. 109)

In Moscow, the famous astronomer Sergei Konstantinovich Vsekhsvyatskii was born on June 7, 1905. In 1925, he graduated from Moscow University and worked for the next ten years at the Astrophysical Institute. From 1935 to 1939, he was an employee and deputy director of the famous Pulkovo Observatory. In 1939, he moved to Kyiv, where until 1981, he worked as a professor, head of the Department of Astronomy at Kyiv University.

He studied the physics of comets, the Sun, and solar activity and was interested in the problems of cosmology and cosmogony. He wrote the book *Physical Characteristics of Comets* (Vsekhsvyatskii, 1958), examined the history of observing comets, mathematically calculated their orbits, and presented the results in the world's first catalogue of the absolute magnitude of comets. In 1932, on a new basis, he developed the hypothesis of J. L. Lagrange about the ejections of comets from the surface of planets and their satellites. In a number of works, he pointed to the influence of planets in the development of solar activity. He was one of the first to suggest the existence of a ring around Jupiter, which was later discovered by the American spacecraft Voyager 1 (1979). He also wrote the book *The Nature and Origin of Comets and Meteoric Substances* (Vsekhsvyatskii, 1967) and co-authored the collective book *Problems of Modern Cosmogony* (Ambartsumyan et al., 1969).

In 1964, in the first issue of the interdepartmental scientific journal "Philosophical Problems of Contemporary Natural Science," published in the Kyiv Order of Lenin State University, named after T. G. Shevchenko, the article 'Philosophical problems of the modern cosmogony of the solar system' was published. This collection contains articles that are original research. In several articles, methodological issues related to natural science, in general, are developed. It was characteristic of Soviet science to seek the interconnection of the most important categories of dialectics in the process of studying natural phenomena and the development of the natural sciences. The aim was to express some questions of the Marxist-Leninist theory in matrix form and to analyse the epistemological principles of planning the development of natural sciences. During the period of Marxism–Leninism, scientists paid great attention to the philosophical and sociological issues of natural science. All this is because K. Marx, F. Engels, and V. I. Lenin, in many of their works, emphasised the importance of this idea; they were convinced that scientific philosophy helps to solve the most important methodological and theoretical problems of natural science. It makes it possible to consistently explain all the achievements of the natural sciences and refute the antiscientific metaphysical and idealistic interpretation of these achievements. Obviously, under the conditions of the dominance of the materialist worldview, there could be no talk of any idealistic concepts.

In his article, Sergei Vsekhsvyatskii claims that the ideas of the first cosmogonic theories were important for Marxists. He compliments F. Engels and his attitude to the nebular hypothesis. Philosophers I. Kant and P. Laplace assumed that the formation of the Sun and planets is a long-term mechanical evolution that essentially excluded dialectics and did not provide for the implementation of dialectical contradictory paths of development. At one time, in science, the task arose to explain only the most general, well-known features of the formation of the solar system; cosmologists were interested in the size and nature of planetary orbits, the ratio of the masses of the Sun and planets, the distribution of the angular momentum, etc.

> "The cosmogonic hypothesis was considered by the authors themselves only as a possible, but not obligatory explanation, as purely speculative knowledge, to a certain extent – a fantasy. In this regard, cosmogonic constructions differ in terms of methodology from other astronomical studies (…) In contrast to the much younger stellar cosmogony, even now the cosmogony of planets remains the cosmogony of the classical direction, the cosmogony of speculative hypotheses, mostly purely mechanistic. The methodology of classical cosmogony corresponded to the period of formation of mechanistic materialism and it turned out to be untenable in the face of many facts, later clarified by the astronomy of the solar system, in front of the dialectical essence of the processes of cosmic nature. Only with the emergence of dialectical materialism did it become possible to really penetrate the essence of the processes of development in the Cosmos" (Vsekhsvyatskii, 1964: 115–116).

The thinker intends to briefly characterise the general methodological features of the classical cosmogonies of Carl Friedrich Freiherr von Weizsäcker (1912–2007), Dirk ter Haar (1919–2002), Gerard Peter Kuiper (1905–1973), John Jamieson Carswell Smart (1920–2012) and Harlow Shapley (1885–1972).

He argues that all the theories that explain cosmogonic processes have one feature that can be noticed if you think about the problem philosophically:

> "In all cases, instead of searching for and revealing the dialectical aspects of development, the processes of formation and evolution are considered from the standpoint of mechanism as the accumulation of unchanging elements, as a simple addition, excluding the dialectical laws of self-development as a result of the struggle of opposite tendencies. But it is precisely this dialectic of self-development that we observe in cosmic processes, where the struggle between attraction and repulsion is clearly manifested and, as a result, a change in qualitative states occurs (…) Only a mechanical perception of the cosmogonic problem – 'antiphysicality' – emphasises the discrepancy between classical cosmogony and real processes. It is with these main shortcomings of the methodology of cosmogonic research that the current stagnation in the study of the past and development processes in the solar system is associated" (Vsekhsvyatskii, 1964: 116–117).

Quite an original statement, which, however, requires philosophical reflection and mathematical justification.

Such attempts to rethink cosmological and cosmogonic research methodologies are not unique. Their number is large, but this does not diminish the importance of various methodologies. On the contrary, it indicates strong scientific interest. So, for example, in the article 'The transcendental method and physical cosmology: an interdisciplinary approach in the research of Ukrainian and Anglo-American philosophers' (Rudenko & Sobolievskyi, 2019), the question of the possibility of applying the transcendental methodology to cosmology was actualised:

> "The philosophers of science have a desire to apply such a philosophical method to the natural sciences, and especially to cosmology. The fact is that space objects are not as they are observed from the Earth, but they represent peculiar phenomena of consciousness. The 'transcendental shift' changed the interest from empirical research to transcendental research, which in turn does not diminish the importance of empirical sciences, but complements the understanding of the results of their research" (Rudenko & Sobolievskyi, 2019: 160).

According to Sergei Vsekhsvyatskii, classical cosmogonies are not able to explain important features of the solar system, particularly the distribution of the density of planetary matter depending on the Sun and geology of the planets. Cosmologists do not use, according to the thinker, the basic principles of the methodology of cosmogonic studies of stars and galaxies, namely, to study not the general but the singular in the phenomena. The point is to pay attention to the rapid transition processes from quantity to quality, which is precisely the essence of the dialectical process. These concepts are very different, but they coexist with one another. This situation is more characteristic of philosophy, as, for example, the researcher Vadym Tytarenko aptly said about German idealism: "The difference in research positions does not allow reducing or 'sublating' (Hegelian term) the theoretical achievements of one thinker by the positions and achievements of another, as it has been deliberately done, for example, in Soviet Marxism" (Tytarenko, 2019: 186). Paying attention to dialectical processes, the author nevertheless does not delve into metaphysics; on the contrary, his views are purely materialistic. A philosophical understanding of the problems of natural science can be based on materialism. Although Marxism is rooted in the religious philosophy of German idealism, it can give a result comparable to the results of research in modern natural sciences, avoiding supernatural concepts. Researcher Liubov Sobolievska rightly argues about the paradigm shift: this is the"reason for penetrating the secrets of nature, which became not the scene of the Biblical story, but the workshop of the scientist" (Sobolievskyi & Sobolievska, 2021: 173).

In terms of the relevance of the astronomical knowledge of Sergei Vsekhsvyatskii today, it is clearly inferior to modern knowledge. Not surprisingly, science has made a big leap in almost 60 years. For example, the author raises the topic of volcanic activity on the planets of the solar system, which corresponds to scientists' ideas of the 1960s. Today, we know that volcanic processes on the Moon are long past, as evidenced by basalt rocks. As for Venus, there is much indirect evidence of volcanic activity, as evidenced by surface radar data. The most interesting evidence for extraterrestrial volcanism comes from Jupiter's Moon Io. The volcanic activity of the planets, according to the author, should have depended on the primary mass of the planets. He suggested that the emissions of light substances increased the density of the planets, and the closer the planet is to the Sun, the faster this process should have progressed.

"This should explain the modern density distribution for planets and high densities for Earth-type planets (Mercury-5.6–6.1; Venus-5.2; Earth-5.5; Mars-4.1; Moon-3.3)" (Vsekhsvyatskii, 1964: 125). Based on these data, the scientist assumes that the original planets of different masses and sizes had almost the same average density as primary stellar matter. In this scenario, the rate of further evolution and loss of matter should have been inversely proportional to the degree of mass. Assuming the initial average density of protoplanets is the same, the scientist represents the distribution of the generalising density by Roche's expression:

$$\varrho = \varrho_0 \left[1 - \xi \left(\frac{r}{r_1}\right)^{\lambda}\right],$$

Where ξ and λ are the parameters of the planets, and r_1 is the primary radius of the protoplanet. With a value of $\xi = 0.96$, according to the scientist, this expression may well satisfy the data (mass, radius, density) for Jupiter; the value $\xi = 0.76$ at $\lambda = 2$ corresponds well to the conditions of Earth (Vsekhsvyatskii, 1964: 125–126). If the protoplanets had the same mass order as the initial configuration set, the central densities should have been close.

He believes that the present conditions of Earth reflect its protoplanetary state, and that the central density is preserved, just as you can check these conditions for other large planets. It should be said that Sergei Vsekhsvyatskii uses the term "protoplanet" in a different sense than Gerard Kuiper or other supporters of the nebular theory. In the understanding of the Soviet scientist, a "protoplanet" is a body that was formed from stellar matter and went through a stage of chemical transformations.

According to this equation:

$$\mathfrak{M} = 4\pi\varrho_0 \int_0^{r_1} \left[1 - \xi \left(\frac{r}{r_1}\right)^{\lambda}\right] r^2 dr = 4\pi\varrho_0 r_1^3 \left(\frac{\lambda}{3} - \xi \frac{1}{\lambda + 3}\right),$$

"We have configurations for $\xi = 0.96$ and $\xi = 0.80$, with value λ, variable from 0 to 5. In this case, ϱ_0 is taken equal to 12.2, as for the Earth. Planetary data show that Mercury, Mars, Venus, Earth fit the curve very well at $\xi = 0.80$" (Vsekhsvyatskii, 1964: 126). Nevertheless, the author does not strive to create a model of the planets or to find out the peculiarities of their evolution; he is trying to prove the same density of "protoplanets" for his cosmogonic studies.

Discussion and Conclusions

The purpose of this article is not to provide a detailed and precise historical analysis of astronomical research in Ukraine. It aims to demonstrate the deep integration of natural science in Ukraine and the legacy of computational and mathematical cosmology in a review of astrophysical research by Ukrainian scientists. On the other hand, cosmology, as a natural science, originated from philosophy, and in cosmology, in addition to mathematical methods, philosophical methods can also be present. Modern philosophy and natural sciences in Ukraine have an interest in interdisciplinary research. "The cooperation between physicists, mathematicians and philosophers in order to identify and explore fundamental issues in cosmology (in the framework of the philosophy of cosmology) resulted in the image of the Universe evolution model" (Bazaluk, 2021). Ludwig von Struve agrees with this thesis, once eccentrically speaking about the connection between cosmology and philosophy: "great philosophical interest. I believe that science has reached the point where it is necessary to take into account the actions of intelligent beings, in addition to the classical laws of physics (Sullivan, 1994). Exploring outer space raises the question about the appropriateness of the

Universe: Are humans the only intelligent species in the Universe? Astronomers seek the answer to this question, as well as physicists and philosophers. However, within the framework of this interdisciplinary study, future research could focus on answering the question about the contribution of Ukrainian scientists to world science against the background of violent and political events.

The article by the Soviet cosmologist argues that in cosmology, there is an unsatisfactory situation in the field of planetary cosmogony. This is primarily due to the application of the classical methodology of the speculative mechanistic hypothesis at that time. According to scientists, this hypothesis cannot reflect the dialectical process of self-development of cosmic bodies. After analysing the article by Sergei Vsekhsvyatskii, we can draw conclusions about his philosophical views on cosmology and cosmogony. He is convinced that contemporary cosmogonic theories are untenable from the point of view of methodology. To demonstrate the inconsistency of this mechanism, which was considered a passed stage in the middle of the 20th century, as a worldview for explaining cosmogonic processes, in his opinion, natural science has stepped forward in the study of the physics of planets and stars; an unprecedented amount of empirical data about space has been obtained, but at the same time, it has weakened its methodological apparatus. If we analyse his views as philosophical, then it becomes obvious that natural science, which is built on natural philosophy in attempts to transform its knowledge into scientific, has lost an important component of a philosophical view of reality, namely critical analysis and the production of alternative opinions. For example, based on the astronomical data of small bodies, a scientist calculated the amount of matter lost by the planets during their evolution. These calculations are important for the cosmologist since mathematics is the scientific community's fundamental science with the true one. In addition, by citing new data, the scientist tries to substantiate the starting points for judging the past of the planets and the planetary system.

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