Essay

Continuing the epistemological analysis of European cosmological knowledge begun in his previous paper *(Herald of the Russian Academy of Science,* 1994, no. 5), the author turns to the discovery made by Copernicus. In the author's opinion, what the great Polish astronomer brought about was not a "revolution" in cosmology and astronomy, but a "turnabout" toward the origins of European scientific and philosophical thought. The author also shows that in the present-day scenarios of an inflationary mechanism of the origin of the universe, one can discern the tradition of the Pythagorean theory of Hestia ("central fire").

An Epistemological Turnabout

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Even a cursory glance at the contemporary methodology and the history of science reveals the radicalism of the once adopted standards and rules explaining the dynamics of scientific knowledge in general and cosmological knowledge in particular. Thus, the generally accepted view that the system of the world put forward by Nicolaus Copernicus as an alternative to the Ptolemaic system signified a "revolution," sometimes called the "Copemican Revolution" is scarcely questioned today [1-41. The conceptual scheme constructed by representatives of postpositivism contained a full set of socio-political terminology of the postrevolutionary world: "crisis," "revolution," "upheaval," "collapse" etc.; such a continuity, wjiich was not confined to terminology alone, far from being concealed, was deliberated emphasized. Word combinations such as "scientific revolution," "scientific upheaval," "collapse of scientific paradigms" and "crisis of scientific theories," which firmly established themselves in methodological usage through the influence of the socio-political sphere on historical-methodological research in the middle of the 20th century, undoubtedly impart a dramatic tone to everyday, at times routine, scientific work. However, they by no means make it more attractive in rational terms—after all, that which is described so dramatically may not correspond to reality at all.

At the same time it would be incorrect to dismiss *in toto* the significance of the heuristic that the sociologically oriented methodology of science brought with it. I shall endeavour to demonstrate, using the "Copemi-can Revolution" as an example, that it is built into a more general and fundamental process than a "scientific revolution" or "change of paradigms" in astronomy and cosmology. In the context of a different scale, the "revolution" performed by Copernicus emerges as a "turnabout" toward the origins of European science and philosophical thought.

The eminent American philosopher and historian of science Thomas S. Kuhn has pointed out that "by the early sixteenth century an increasing number of Europe's best astronomers were recognizing that the astronomical paradigm was failing in application to its own traditional problems. That recognition was prerequisite to Copernicus' rejection of the Ptolemaic paradigm and his search for a new one" [1, p. 69]. What specific reasons (apart from the general scientific back-ground) were there underlying such a search? Kuhn points to a "breakdown of the normal puzzle-solving activity" in scientific progress, the "social pressure for calendar reform " the "medieval criticism of Aristotle " and "the rise of Renaissance neo-Platonism." But, he emphasizes, "technical breakdown would still remain the core of the crisis" [1. p. 69].

Indeed, in his Epistle to Pope Paul III, Copernicus gave as a motive for his work the need to eliminate a number of substantial faults in the then reigning Ptolemaic system, among which he listed the fact that scientists "cannot even explain or observe the constant length of the seasonal year," their failure "to use the same principles and hypotheses" in describing the motion of celestial

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bodies and wandering stars ("som(use only concentric circles, while others employ eccen tries and epicycles"), and "the incompatibility oftheor and observation" [5, p. 4]. As a result—and this was th most important of all to Copernicus—neither the shap of the world nor the exact proportionality of its par were determined. "It is as though," Copernicus wrot "an artist were to gather hands, feet, head, and oth members for his images from divers models, each *pг* excellently drawn, but not related to a single body, ai since they in no way match each other, the result wou be monster rather than man" [5, p. 4].

Such a vividly depicted state of affairs in astronoi and cosmology can simply be described as disorder. the whole, the state of European science and philo phy by the 16th century was one of epistemologi chaos, of an absence of clearly defined facets or bou

aries of the world. Little wonder that it was with the introduction of order that the rebirth of science actually began. It should also be remembered that "order" in the original sense of the word was tantamount to the Cosmos, and the discipline directly concerned with it is cosmology. The first relevant basic treatises—*De Rev-olutionibus Orbium Caelestium* (On the Revolutions of the Spheres of the Universe) by Copernicus and *Dial' ogo del Due Massimi Sistemi del Mondo* (Dialogue on the Two Principal Systems of the World) by Galileo— had cosmological titles for the very reason that they sought to establish an orderly "world system."

To this day it remains unclear what Copernicus did when he discovered the faults of the Ptolemaic system. Kuhn asserts that he first of all tackled technical puzzles and, when he became convinced that they could not be solved within the framework of the old system, he rejected it [1, p. 149]. There is no denying this. The main question, however, is: what served as the reason (or stimulus) for the change of perceptions? Kuhn says on this score that the scientist "will, in the first place, often seem a man searching at random, trying experiments just to see what will happen, looking for an effect whose nature he cannot quite guess" [1, p. 87]. This is a picture of absolutely indeterminate activity, with the scientist completely relying on chance and the new paradigm proving to be a stroke of luck. But then Kuhn stipulates its horizon: "Since no experiment can be conceived without some sort of theory, the scientist in crisis will constantly try to generate speculative theories that, if successful, may disclose the road to a new paradigm and, if unsuccessful, can be surrendered with relative ease" [1, p. 87]. Such a strategy can in all conscience be called a method of "trial and error," of, in effect, sifting physical, cosmological, or any other reality. It bears the clear imprint of the spirit of neo-Euro-pean "empiricism" and at the same time contains a grain of the revolutionary approach—it matters not whether in science or in society—that the end justifies the means. From Kuhn's words it is obvious that "theory" is understood not in its original meaning: as an end in itself, as "scrutiny-discernment," but merely as "support" for experimenting, as a background for it. It is this that gives birth to "His Majesty Chance" and the method of "trial and error." To see how justified such a conclusion is, let us return to the work of Copernicus.

The author of *De Revolutionibus* by no means relied on a chance solution of baffling conundrums (the elimination of equanta, etc.); nor did he even attempt to produce speculative "working" theories. What did he do? Let us quote his own explanation. "I began to chafe that philosophers could by no means agree on any one certain theory of the mechanism of the Universe ... I therefore took pains to read again the works of all the philosophers on whom I could lay my hand to seek out whether any of them had ever speculated that the motions of the spheres were other than those demanded by the mathematical schools. I found first in Cicero that Nicetas had realized that the Earth moved. Afterwards, I found in Plutarch that certain others had held a like opinion. I think fit to add here Plutarch's own words, to make them accessible to all: 'The rest hold the Earth to be stationary, but Philolaus the Pythagorean says that she moves around the central fire on an oblique circle like the Sun and Moon. Heraclides of Pontus and Ecophantus the Pythagorean also make the Earth move, not indeed through space, but by rotating round her own center as a wheel on an axle from West to East.' Taking advantage of this, I too began to think of the mobility of the Earth" [5, pp. 4-5].

Where is there a "random experiment" here, with its consummation fortunate for the experimenter, or practice of the method of "trial and error"? The quoted passage provides no grounds for agreeing with Kuhn about two "triggers" of the mechanism "switching the perception" of the researcher to a new paradigm. Copernicus literally turned from the system of Eudoxus (which received physical support in the writings of Aristotle, became established in ancient science and philosophy thanks to the latter's authority, and was then perfected by Ptolemy) to another branch of ancient thinking—the Pythagorean and Platonic wellsprings.

In chapter 11 of book one of *De Revolutionibus^* in which he proves the triple motion of the Earth, the author cited geometric arguments of a strictly theoretical character that are far removed from the spirit of "random experiments." Copernicus himself, far from concealing, deliberately emphasized the predominance of the hypothetical-deductive (basically theoretical) method over that of "trial and error." His main hypothesis consisted in claiming that the "diurnal motion of the Earth about its axis, its annual motion around an assumed center, and the motion of obliquity (declinational motion) compel the Earth's axis to remain in one and the same position, with everything appearing as if this was the motion of the Sun" [5, pp. 38-39]. The author referred directly to the source of his hypothesis:
"... on the basis of these and similar considerations, Philolaus arrived at the view that the Earth moves;
some say this was also the opinion of Aristarchus of Samos, and neither one of them was impressed by the reasoning cited and censured by Aristotle" [5, p. 39]. In the concluding part of the chapter, Copernicus even quoted his translation of a message from Lysis to Hip-parchus to emphasize how difficult had been the survival of convictions that could be comprehended only by a "keen mind" in the conditions of the Pythagorean corporative circle and the simultaneous extensive circulation in later antiquity and the Middle Ages of the erroneous views of Aristotle on this subject.

A natural question arises at this point: surely Kuhn could not have ignored the Pythagorean continuity of Copernicus's "discovery"? To give a satisfactory answer to this question it is necessary to understand how he explained the phenomenon of Pythagoreanism and Pythagoras's followers—Heraclides Ponticus and Aristarchus of Samos—in the context of the exposition

of the stmcture of the world and how Pythagoreanism fits (or, on the contrary, does not fit) into Kuhn's model of a "paradigm shift." It is obvious that recognition of the significance of this phenomenon in antiquity implies that the said model (and, with it, all its modifications, with their implications of "scientific revolutions," "collapses," and "crises") will simply remain suspended in midair. It is also evident that Kuhn—to establish the importance of the "Copernican Revolution" in the 16th century, i.e., to demonstrate the shift of paradigms in that epoch—seeks to minimize the role of Pythagoreanism, to depict it as an "incomprehensible hieroglyph" in antiquity. That is exactly how Kuhn assesses the ancient Greek helio-Hestiacentrists in his book *The Copernican Revolution* (1957). "These alternative cosmologies ... are remarkably like our modern views," he writes. "We do believe today that the earth is but one of a number of planets circulating about the sun, and that the sun is but one of a multitude of stars, some of which may have their own planets. But though some of these speculative suggestions gave rise to significant minority traditions in antiquity, and though all of them were a continuing source of intellectual stimulus to innovators like Copernicus, they were not originally supported by the arguments that now make us believe them, and in the absence of these arguments they were rejected by most philosophers and almost all astronomers in the ancient world" [2, p. 42].

Copernicus cited a host of arguments of this kind, but considered one of them to be basic: concerning the triple motion of the Earth, which, he believed, had prompted Philolaus and Aristarchus of Samos to espouse the helio-Hestiacentric interpretation of the structure of the world [5, p. 39]. Consequently, it is most likely that the crux of the matter lies not in his own cosmological

and astronomical reasoning, but in something else. That something is noted by Kuhn as well: "These alternative cosmologies violate the first and most fundamental suggestions provided by the senses about the structure of the universe" [2, p. 42]. In other words, the epistemological weight of the manifest world prevailed over the weight of the nonmanifest. And the empiricism of Aristotle in explaining the physical world was, unquestionably, more in keeping with the "diurnal rotation of the firmament" observed with the help of the senses. The authority of Aristotle, who had epistemologically justified the sensory (empirical) manifestness of the geocentric system of Eudoxus, in this case played an "outstanding" negative role. For a graphic illustration of this, I shall quote one of the most current "manifestness arguments" that he put forward against the Pythagorean theory: "On the other hand, the Italian philosophers, known as Pythagoreans, take the opposite view: at the center, they argue, is the fire, while the Earth—one of the stars—travels in a circle around the center, causing the alternation of day and night... the Pythagoreans, not seeking theories or explanations conforming to the *observed* (my italics—A.P.) facts, but adducing far-fetched arguments and trying to
fit them into some kind of theories and views of their own" *[On the Heavens,* II, 13, 293a20-27]. Why does Aristotle not agree with the Pythagoreans? Here is how he himself explained it. "It is directly manifest and accepted as an axiom that the universe circumvo-lutes ..." (That is, it is not the Earth, but only the firmament that revolves around the Sun.) Moreover, he formulated something in the nature of an epistemological principle: "We can assert with sufficient grounds only what we observe in reality in many or in all cases" *[On the Heavens,* I, 10, 27917-21]. In other words, for Aristotle, as for hundreds of thousands and millions of other people, "directly manifest" sensory observations were the most weighty argument of all. That was believed in the 4th century B.C. and in the 16th century A.D. Nothing in principle changed in two thousand years. Little wonder that if even such a patriarch of ancient philosophy and science as Aristotle preferred "observable facts" to "speculative reasoning," helio-centrism could scarcely win popularity among his contemporaries. Manifestness as a key argument played a fatal role in shaping human notions about the structure of the Cosmos-Universe even in antiquity. As for Aristotle's "empiricism," it acquired the status of "holy writ," to which most philosophers and scientists turned without proper reflection or criticism in the days both of Philolaus and of Copernicus.

Kuhn is perfectly aware that the main obstacle to the "spread" ofheliocentrism was its by no means obvious nature. "The idea that the Earth moves," he says, "seems initially absurd" [2, p. 43]. At the same time he fails to note a significant fact: the initial models of the nonmanifest world arose first and foremost among the Pythagorean mathematicians, who made epistemological reliance on nonmanifestness the pivot of all their views on the world. It was the speculative character of their convictions that gave them that "freedom of scientific quest" that was so lacking in the "empiricists of antiquity," who discerned in this nothing but "far-fetched arguments." It is for this reason that Kuhn considers that "the incompatibility of theory and observation is the ultimate source of every revolution in the sciences" [2, p. 75]. However, as the history of the Copernican, relativistic, and inflationary cosmology shows, that which he calls a "revolution" occurred not thanks to such an "incompatibility" but for purely "speculative reasons." A breakthrough invariably occurred either whenever an argument concerning the manifest character of observed facts was brought into question or whenever the observed facts were not taken into account at all (prior to Alexander Friedman the evolution of the Universe as a whole had, naturally, not been observed by anyone, let alone observations of the inflation of the Universe, which occurs, according to the inflationary theory, at an early stage of its evolution).

The well-known American historian of science B nice Wrightsman has proposed a "reformist" rather than "revolutionary" version ofCopemicus's discovery [6]. Although I am considering the latter's work from

the standpoint of epistemology rather than the history of astronomy or biography (as Wrightsman does), I would fully subscribe to his statement that if the term "revolutionary" implies some event or movement initiating a process that in a relatively short time irreversibly alters the structure and development of an established system, then—in that sense of the term—Copernicus was not a revolutionary. Copernicus, Wrightsman points out, set himself the goal of reanimating astronomy. His methodology and arguments remained conventional. And his principal idea—that the earth moves—was most certainly not novel. The novelty was in the fact that this idea and the consequent cosmologi-cal system were asserted as a truth [6, p. 298].

Even the ancients realized that it was difficult not to fathom the truth and be in it—to restore the true world system to its rightful status, but by no means overturn the world, as the advocates of "revolutionary" approaches would have us believe. It is well known that already Aristarchus of Samos almost paid the price of his life for his heliocentric convictions. And Aristotle's ridicule of the "speculative thinking" of the Pythagoreans and Plato continued to circulate until the 17th century, albeit clothed in church dogmas. This being so, Copenicus's accomplishment was, in the literal sense of the word, a scientific feat.

The case of Copernicus throws light on the intellectual climate in which took place not a "revolution" of views on the Universe hut—what is far more important for understanding European science and the prevalent type of rational thinking among its founders—a turnabout toward the Pythagorean wellsprings of antiquity. By breaking with the Aristotelianism of Ptolemy and his followers in favor of Pythagoreanism and Pla-tonism, European cosmology did not simply replace one paradigm with another. By quitting the wrong path, it made possible an adequate reflection of reality.

The following are, in my view, the most significant features of this turnabout.

• It was based on the profound epistemological premise that it is wrong to proceed from notions only about the manifest world and on the conviction that true knowledge about the physical and cosmological structure of the world cannot be acquired by relying only on the manifest qualitative world. Even here, we observe a turn away from the "qualitativism" of Aristotle, in whose opinion genuine physical knowledge boiled down to that which we definitely perceive via our senses *[On the Heavens,* III, 7306al6-20], to the Pythagorean-Platonic "quantitavism," which accepted that valid physical and cosmological knowledge could be derived from the area of the nonmanifest—via the mental deduction of mathematical relationships. To a considerable extent, the turn toward consideration of the nonmanifest in the physicocosmological world in Copemicus's time was stimulated by the analysis of the "relative nature of motion," begun by N. Kouzanski (who had an indisputable influence on Copernicus) and consummated, probably, only by the principles and laws established and discovered by Galileo. A substantial contribution to understanding the "nonmanifest" was also made by astronomical research proper: the consideration of the nature of reflected light, the analysis of the three motions of the earth, etc.

• It signified a realization of the fact that the physicocosmological world can be described most adequately in qualitative terms only provided it has been described and explained numerically-theoretically (i.e., mathematically). This too reflects a turn toward Pythagoreanism and Platonism. Numbers began to occupy as predominant a status in interpreting the entire world system as they had occupied in the work of the Pythagoreans and Plato [8]. In a certain sense, it is only through numbers that the qualitative world can indeed be understood.

• It signalled a revival of the Pythagorean concept according to which the earth does not just have a diurnal rotation and is not motionless (resting at the center of the Universe, as assumed in Aristotelian scholasticism). The point at issue is the existence of the central fire in place of which Copernicus put the sun.

I have already analyzed the fact that the first two of these propositions became firmly established in scientific cosmology and physics and have not undergone any substantial modifications right up to our day [9,10]. The situation is much more complicated with respect to the third proposition, for the proposition concerning the "heliocentric structure of the Universe" is considered indisputably correct in speaking of the solar system in its present-day interpretation and absolutely incorrect if the sun is presumed to be the center of the entire Universe. Let us dwell in greater detail on this feature of the Copemican Revolution. Thanks to surviving fragments of the writings of Philolaus and other authors, Copernicus undoubtedly knew of the Pythagorean idea of a central fire, which was, however, distinct from the sun. In other words, for the Pythagoreans, the center of the "solar system" and the center of the Universe did not coincide.

Today we can only guess why Copernicus shifted the center of the Universe by a mere eight light minutes, remaining silent about the Pythagorean Hestia— whether he preferred to deal with visible celestial bodies only, or was motivated by some other considerations, say, the principle of simplicity. But the fact that he placed the luminous fire, the sun, at the center of the Universe, in my view, reflects not just a wish to "shift the earth." Let me explain this ...

The question of the Pythagorean central fire is considered very complex by historians of science and philosophy. For example, J. Bumet's analysis of Plato's dialogues *Phaedo, Timaeus,* and *Philebus* led him to

[1] For a more detailed consideration of the "speculative" nature of th€ Copemican turnabout built into the "speculative" tradition of science as a whole in the later Renaissance, which was opposed to the "manifest world" of Aristotelian physics and cosmology, see (7)].

conclude that "the teaching about the central fire belongs to a later generation of the school [Pythagoreans—A.R] and Plato could have learned about it from Archytas and his friends after he had written his *Phaedo"* [11, p. 274]. In Bumet's opinion, the heliocentric hypothesis follows from Empedocles' theory of sunlight. "The meaning of this," he wrote, "is that the central fire was in reality the sun, which Philolaus, however, unfoundedly doubled, explaining the visible sun as a reflection of the central fire" [11, pp. 274-275]. This conclusion is shared by F. Steigmuller, H. Diels, and certain other scholars, who assumed that identifying the central fire with the sun was characteristic of Plato's disciple Heraclides of Pontus, to whom, along with Aristarchus of Samos, they likewise attributed the heliocentric hypothesis. In Bumet's words, Aristotle's attitude to the heliocentric theory had the result that "Copernicus had to discover the truth anew" [11, p. 276]. A notable exposition of the "turnabout"!

There is thus reason to speak of a tradition of reducing the interpretation of the central fire (Hestia) by Philolaus and his fellow-Pythagoreans to identification with the sun and attributing the resulting misunderstanding—the doubling of the celestial bodies—to a misinterpretation of the sun as a "reflection" of the central fire. Such an approach makes it possible to see the origin of Copemicus's hypothesis in retrospect and to put everything in its proper place. However, the tendency to modernize ancient texts and to interpret them from the viewpoint of present-day notions seems hardly productive. Let us try to answer several questions. Was the doubling of celestial bodies—the central fire and the sun—really a consequence of a failure to understand the "genuine" rather than reflected nature of the luminosity? Or was there a different reason here that escapes the modernizing view? What did the Pythagoreans mean by a central fire—apart from the property of any fire to emit light and warmth?

The Pythagorean Cosmos is defined by its center— Hestia—around which everything revolves, including the sun. "Philolaus [places] the fire in the middle, in the center, which he calls the Hestia of the Universe, the home of Zeus, the mother and altar of the Gods, the bond and measure of nature." Hestia turns out to be the center of the entire Cosmos. But is this a reference to a geometric and only geometric center? An original answer to this question has been given by A.L. Dobrokhotov. "Home-fire-center are the notions on which the image of the Hestia mythopoeia rests. For example, Delphi was the "Hestia" of the Hellenic world. This was also so because Delphi was the 'hub[9] of the Universe, because Delphi was the site of the sacred fire, and because it was the religious center of Greece, its 'home'" [13, p. 25]. According to Stobaeus, the central fire is encircled "by a roundelay of ten divine bodies, the sky, and the planets; beyond which is

[2] Here and below the pronouncements of the pre-Socratics are quoted according to [12].

the sun; beneath which is the moon; beneath which is the earth; beneath which is the counterearth (Antich-thones), and after them all, the fire of the Hearth, which occupies the central position." Here one cannot but recall Plato's own interpretation of Hestia in *Cratylus,* According to Plato, the term may be traced etymologi-cally to the word *usia,* which means "the essence of things" and is pronounced by some people as "Hesia"

In the Pythagorean tradition, Hestia occupies a central—substantive—status by no means accidentally. It is the source of the fire that then engulfs the entire Cosmos. Plato's hermeneutic intuition, contested or even completely dismissed by the overwhelming majority of historians of philosophy and philologists, nevertheless merits close attention. In the above-quoted passage from Dobrokhotov, it is not a notion of, so to speak, a scientific category that is implied. Hestia precisely as a hearth is not just literally the geometric center of the world. Since the principal object of Dobrokhotov's inquiry is *being,* it may confidently be concluded that Hestia is the center of being in the Universe. In this sense it "gathers around itself the entire Cosmos, keeping it thereby in proper order. But even such an interpretation is a mere statement. Yes, Hestia is the metaphysical center of the Universe. But why? For the same reason that we can say that the center of Russia is situated not somewhere east of the Urals as is the geometric center, but in the Holy Trinity-St. Sergius Mon-astery; similarly the center of the Monastery is not its geometric center formed by the walls of the Monastery but is the place where the Trinity Cathedral stands, and the center of the Cathedral is not the point of intersection of straight lines drawn from distant and near points on the surface of the Cathedral but the site where the shrine of St. Sergius is situated. Thus, just as the center of the Hellenic world was situated in Delphi, so the center of Russia lies in the Trinity Cathedral. This center is the source [14] and truth, the truth of metaphysical life. Situated in Delphi is the Hestia of Ancient Greece; in the Trinity Cathedral, the Hestia of Russia. It was this that Plato brilliantly grasped and interpreted as the essence.

Philolaus maintained that Hestia was "the first harmoniously organized entity at the center of the (world) sphere" and that "the world is one whole and began to form from a center." Trubetskoi, in a comment on these words, called Hestia "a divine body formed prior to the beginning of the world, prior to the beginning of all time, for time itself is born of its breathing" [15, p. 216]. He even believed that, by his theory of the breathing of the world, Pythagoras had "influenced the teachings ofAnaximenes" [15, p. 214], who had recognized the air, at times densifying, at times rarefying, as the absolute beginning.

In my opinion, the Pythagorean conception of the Cosmos-Universe anticipated many ideas of present-day cosmology. It anticipated them in the sense that fire-hearth-Hestia is that "center" from which the fiery

inflation of the Universe proceeds. But even in present-day scientific descriptions, it cannot be "shown," since, apart from this Universe, which prescribes the scale of reference, there is no other in whose coordinates such a center could be singled out. In the 1920s, Friedman discovered that the "radius" of the Universe (the scale factor) vanishes at the moment of time $t = 0$, and the density of matter and the curvature tensor of space become infinite. This is what is termed the initial cosmological singularity. Supported by the discovery of the microwave background (relic radiation) with a temperature T^{w} 2.7 K, the model of the hot Universe has come to be generally accepted. What is noteworthy for us in this model is the fact that the singularity turns out to be the genetic center from which the entire Universe arose, although the size of the region from which its visible part formed was of the order of 10~^{4}. However, because it is absolutely everything, the question of its geometric center is senseless. The Universe is expanding, but the "radius" of the expanding Universe is spoken of by convention, for in reality it is the scale factor that is meant. It is as if a point were inflating, but actually it is inflating in its entirety, and for this reason it has no center in the geometric sense of the term.

As early as the very beginning of the epoch of the construction of inflationary scenarios (in the 1970-1980s), the absence of a basis for recognizing a reference system in its classical neo-European meaning evoked strong criticism and reproaches of a "lack of realism" leveled at the approaches proposed by A. Guth, A. Albrecht, P. Steinhardt, A. Linde, and others for the very reason that it was "empty" space that was inflated [16]. Up to now the presence of a material substance—whether a material body or a physical field—was considered essential in physics and cosmology for establishing a reference system. The fact is that the process of inflation is associated with the scalar field (p, although other fields may figure in some scenarios. The substantive (meaningful) site of the "Pythagorean fire" in inflationary scenarios is the energy of a vacuum whose density is negative, which is expressed by the Gleener equation of state P = -(p. A significant feature of negative energy density is the fact that, when accumulated by a field, it is converted to thermal energy with the subsequent birth of matter.

The presence of such a field throughout space does not give rise to any related reference system because, as Linde has explained, the Lagrangian of the equation is relativistically invariant irrespective of the value of (p [17, p. II]. Actually, there is a transition of the vacuum from a state in which the minimum of the effective potential is at zero to a state in which that minimum is at a point other than zero. This process has come to be known as a "vacuum state transition." This paved the way for the construction of subsequent scenarios. The newly emergent field (p alters the masses of the particles interacting with it. This, in turn, causes spontaneous symmetry breaking, for up to this moment, all the vector mesons, which were energy carriers, had no mass, which made the various types of interaction indistinguishable. After symmetry breaking, the temperature of the matter rises and the homogeneous scalar field (p vanishes. That is how the evolution of the "separate domain" was described. But in 1983 Linde for the first time proposed the scenario of the chaotically inflating Universe, in which there may be an unlimited number of regions filled with the (p field, and these regions give rise to others filled with a similar field. However, the classical description of inflation for the visible world still remains valid. In other words, although the evolution of the chaotically inflating Universe, according to Linde, "has no end and, possibly, has no single beginning" [17, p. 211], the inflation of the Universe we observe took place as described in the foregoing.

And today, recognizing that we live in a spherical world (domain), we should be able to determine its geometric center, which, however, need not coincide with the genetic center—the point $10\sim^{33}$ cm in radius where inflation began. The power of the heating of the scalar field (p—the genetic origin of the visible Universe—can be likened only to the Pythagorean fire.

The Pythagorean Hestia by its acts of inhalation and exhalation produces motion and, hence, everything that serves as the numbers of time ("wandering" planets) and time itself. Inhalation and exhalation correspond to centripetal and centrifugal fluxes of the contents of the Cosmos. (Significantly, 20th-century cosmology has established that "exhalation" is typical of the spherical Universe.) The visible region of the Universe did not simply expand to its present state, but largely "inflated" to it. And it is the purely physical process of "inflation," strange as it may seem, that made it possible to solve the overwhelming majority of the cosmological problems of the end of the 20th century. Contemporary cosmology has even determined that the epoch of "exhalation" began some 14 to 15 billion years ago.

Actually, the Pythagorean interpretation of the breathing nature of Hestia foresaw such a property, which was not accepted by many at the time. By absorbing the limitless (vacuum), the central fire incorporated it in itself and, by limiting it (literally imposing a limit on the limitless), it defined it and thereby created the world. Therefore, the Cosmos, according to the Pythagoreans, is merely that part of the world to which the organizing power of the hearth—Hestia—extends, for fire does not only govern the "sky" from the center, but encompasses its highest sphere, Olympus. As Tru-betskoi aptly put it, Zeus, the ruler of the world, "lives in Hestia on Olympus: Hestia is his sacrificial altar, the support of his throne; Olympus, his heavenly home; Hestia is his center point, his watch tower from which he surveys the world and guards it; Olympus, an impregnable wall, the fortification of the world" [15, p. 219]. Surprisingly, the idea of the ancients about an "extreme sphere of the Universe," which appears to have arisen even before Pythagoras, has found something in the nature of support in present-day scientific

concepts. This is clear from the empirical studies aimed at discovering indirect evidence of the existence of "walls" of the domain: a sphere of our Universe. The existence of domain walls—large-scale inhomogene-ities—is one of the predictions of inflationary cosmology-

Thus, insofar as Hestia is a measure of the Cosmos, it measures its time and place, determines it, and governs it. By criticizing the Pythagorean explanation of the structure of the Universe, Aristotle became the next in a series of those—since the creation of the Copemi-can world system—who found themselves in the position of a thinker whose views on the Cosmos and the Universe were proved wrong on a number of fundamental issues. Thus, in chapter 11 of book 1 of the treatise *On the Heavens^* he took exception to the "emergence of anything in the sense of a transition from non-being to being" which he rejected as "absolutely impossible" (280bl0-15), and in chapter 10 he spoke of the impossibility and, indeed, "absurdity" in general of any creation of the Cosmos. He also levelled scathing criticism at Plato's idea of the origin of the Cosmos (artificed by Demiurge) from a chaotic state of matter—somewhat analogous to a contemporary vacuum—which later church theologians (St. Just and Clement of Alexandria) called "shapeless matter."

Perhaps, without realizing it, contemporary cosmology is actually continuing a controversy begun two and a half thousand years ago by the Pythagoreans and Plato, on the one hand, and Aristotle, on the other.

My analysis prompts ^wo major conclusions. The first concerns the essence of the evolution of scientific cosmology in our century. It has to be admitted that it has been keynoted by a return to the origins of European scientific and philosophical thinking, regardless of whether or not this was realized by the participants in the process.

Copernicus, as early as the 16th century, actuated the mechanism of a "turnabout" toward the Pythagorean-Platonic tradition, which as far back as two and a half thousand years ago had cast doubt on the veracity of knowledge of the Universe based on manifest notions of the world. Then, from about the end of the 17th century, there was something like a restoration of ancient materialism and empiricism. There was a revival of the Aristotelian proposition that proclaimed reliance in physical learning on sensory perception of the qualitative world (this principle in the new conditions took root primarily on English soil) and also a reversion to Democritean views on the infinite character of the Universe. It was only at the beginning of the 20th century that a new epistemological turnabout took place: back to the Pythagorean-Platonic tradition. First of all, the development of the special theory of relativity and the general theory of relativity once again brought into question the correctness of manifest notions about the world (the relativistic contraction of spacetime segments, not to mention the fact that the geometric explanation of the nature of gravitation is equivalent to the field explanation). To be sure, there is no question of rejecting the obvious (visible) qualitative world or the possibility of a visible (experimental) verification of physical-cosmological knowledge. It is merely assumed that this obvious world becomes adequately explicable and understandable when it is interpreted on the basis of knowledge of the forces operating in a nonmanifest world, and that there is not and cannot be any evident cause-and-effect chain between these worlds. One of the reasons why the Pythagorean and Platonist Galileo found it very difficult to conduct a debate with Ingoly was the fact that he could not, as required by Aristotle's "qualitativism," point his finger at inertial motion. The Pythagorean and Platonist Copernicus, in turn, could not enable his opponents to "behold" the triple motion of the earth. Many physicists at the end of the present century cannot comprehend what is meant by the inflation of "empty" (lacking matter or radiation) space.

Furthermore, it was realized that the only road that could lead—more or less effectively—to unravelling and reflecting the nonmanifest world was the language of mathematics and that this language was based on the strange parallelism between numbers and matter. As a result, there also began a quest for an "equation of the Universe " from which the material world itself in its specific

manifestations would follow as a corollary. By creating the general theory of relativity, Albert Einstein derived the "equation of the Universe" from field equations in a "natural" manner. This equation of the Universe was afterwards modified by Friedman in the form of three of its solutions without the X-term. This step was a perfect example of the Pythagorean approach to explaining the structure of the Universe—not in specific details, of course, but in principle, with gravitation understood both as a property of matter (field) and as a property of curved space. But in the latter case, physics follows from geometry, and not *vice versa.* An attempt by Einstein's pupils to construct a geometrodynamics was a very impressive example in this respect [18]. Another, no less weighty argument was theWheeler-de Witt wave function of the Universe
ти,ф),
where *h,* i, *j* is a three-dimensional space metric, and (p are the fields of matter. Presumably, attempts to create a theory uniting all the known types of interactions will yield even more unexpected results.

Finally, at the beginning of the century it was proven strictly mathematically that the observed Universe had a beginning in time and space. That brings us to a second major conclusion: the turnabout (witting or unwitting) toward Pythagorean principles of explaining the structure of the Universe makes it possible to note the existence of a certain chain, which could seem quite unfounded, but which nevertheless remains a fact.

The Pythagoreans believed the central fire (Hestia) to be the center of the world or, as Plato put it, the
essence of the world. Copernicus, as shown in the foregoing, proceeded in the same direction, placing fire— the sun—in the center of the world. Then there was a gap in the tradition, and this eliminated all centers. It was only in the 20th century that a clear turnaround toward Pythagoreanism took place, including the issue of a center. The concept of a central fire reappeared, at first in the 1920s, when it was understood as a singularity in the theory of the Big Bang, and lately as a "meaningful" fluctuation of the (p scalar field, which has a negative energy density in inflationary scenarios.

We have thus witnessed a new epistemological turnabout toward the Pythagorean-Platonic origins of European science and philosophy. And there is reason to hope that new frontiers will be reached along this road in understanding the structure of the Universe. At any rate, historical "statistics" show: every return of cosmology to the Pythagorean principles of explaining the Universe signified a breakthrough in understanding its structure and, conversely, a departure from principles that brought stagnation upon cosmology.

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