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TRANSLATION

Translation of Jan Patočka's "Galileo Galilei and the end of the ancient cosmos"

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Abstract
Jan Patočka's "Galileo Galilei and the End of the Ancient Cosmos" was initially published in the popular science journal *Vesmír*, 33 (1954), no. 1, pp. 27–29. The year before, there had been published in the same journal, under the general heading "On the Development of the Ideas of Natural Science," a series of Patočka's articles, including "The First Critics of Aristotelianism" [*Vesmír* 32 (1953), no. 7, pp. 254–256]; "The Breakdown of Aristotle's Dynamics and the Prelude to Modern Mechanicism" (ibid., no. 8, pp. 285–287); "Intermezzo on the Threshold of Modern Science: Cusanus and Comenius" (ibid., no. 9, pp. 322–325). This series had been introduced by yet another text: "Aristotle's Philosophical Natural Science" [*Vesmír* 32 (1953), no. 3, pp. 102–105]. A last short essay on the theme of the birth of modern natural science—"On the Significance of Francis Bacon of Verulam" [*Vesmír* 40 (1961), no. 5, pp. 152, 155, and no. 6, pp. 186–188]—followed several years later. These texts were all subsequently revised to a greater or lesser extent and included in the book *Aristoteles, jeho předchůdci a dědicové* (Aristotle, His Forerunners and Successors), Prague: NČSAV, 1964.

Keywords Galileo · Cosmos · Modern science · Aristotle

On "Galileo Galilei and the end of the ancient cosmos" by Jan Patočka

Jan Patočka, the most significant Czech philosopher of recent time, was a talented student of Edmund Husserl. As one of the leading personalities in the European phenomenological movement, he embraced an extraordinarily wide spectrum of

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problems. Many of the questions addressed by Patočka emerged in previous periods of Western thought, and the influence of his thought persists even today. Similar to Max Scheler,[1] another phenomenological philosopher and former student of Husserl, Patočka was well informed about the development of natural and social sciences. Despite his rejection of positivism as a result of the modern belief in permanent technical progress, it is evident that Patočka endeavored to base his teachings on the scientific research data available in his time.

The text translated below was published for the first time in the journal *Vesmír* (*Universe, Kosmos*) in 1954 under the title "Galileo Galilei a konec antického kosmu"[2]. However, this was not Patočka's first contribution to the journal; on the contrary, he was a regularly published author who had been contributing to this popular science journal since 1953 through a series of articles entitled "O vývoji ideí přírodních věd" (On the Development of the Ideas of Natural Science). This series included texts such as "Aristotelova filosofická přírodověda" (Aristotle's Philosophical Natural Science),[3] "První kritikové aristotelismu" (The First Critics of Aristotelianism),[4] "Rozklad Aristotelovy dynamiky" (The Breakdown of Aristotle's Dynamics), "Přelud k modernímu mechanismu" (Prelude to Modern Mechanicism)[5] and "Mezihra na prahu moderní vědy Cusanus a Komenský" (Intermezzo on the Threshold of Modern Science: Cusanus and Comenius)."[6] Patočka's final essay on the topic of the development of modern natural sciences appeared in the journal in 1961 under the title "O významu F. Bacona" (On the Significance of Francis Bacon of Verulam).[7] After revisions, the series of articles was incorporated into a book entitled *Aristoteles, jeho předchůdci a dědicové* (Aristotle, His Forerunners and Successors),[8] which was published in 1964 in Prague.

In his essay "Galileo Galilei and the End of the Ancient Cosmos," Patočka attempts to foreshadow the way in which Galileo's purely mechanical understanding of movement changed the general image of the cosmos, in contrast to the previous Platonic and Aristotelian theories of movement. This important change, notable even in the present time, has had a significant impact on contemporary thought. According to Patočka, Galileo Galilei was overly concerned about the reconciliation of the Platonic and Aristotelian philosophical traditions. This conflict emerged in the early Middle Ages and was a major theme in the sixteenth century, and its reach extended to the modern and postmodern periods of Western thought. In the twentieth century, philosopher Martin Heidegger strongly accentuated the opposition between Platonic and Aristotelian

[1] Patočka wrote an extensive introduction to the Czech translation of Scheler's key work, *Die Stellung des Menschen im Kosmos*. See, Scheler, M.: *Místo člověka v kosmu.* Tr. by A. Jaurisová. Praha: Nakladatelství ČSAV 1968, pp. 7–47.

[2] In *Vesmír*, 33 (1954), no. 1, pp. 27–29.

[3] In *Vesmír* 32 (1953), no. 3, pp. 102–105.

[4] In *Vesmír* 32 (1953), no. 7, pp. 254–256.

[5] In *Vesmír* 32, no. 8, pp. 285–287.

[6] In *Vesmír* 32., no. 9, pp. 322–325.

[7] In *Vesmír* 40, no. 5, pp. 152, 155, and no. 6, pp. 186–188).

[8] Patočka, J. (1964). Aristoteles, jeho předchůdci a dědicové. Prague: NČSAV.

philosophy. However, his student Hans-Georg Gadamer was convinced that the two traditions were in unity, referring to Aristotle as a critical Platonist.[9]

In his endeavor to constitute a common platform for Platonists and Aristotelians, Galileo attempted to create an alternative understanding of the cosmos that was based on the newly established natural sciences. The ancient map of the cosmos had a hierarchical structure in which purely spiritual beings were at the top and material beings were at the bottom. Galileo's image of the cosmos was identical to a sum of objects, all of which stood at the same level. In ancient thought, spiritual beings were more significant and more powerful than material beings, and they represented the purpose and cause of everything that happened to the lower beings. Hence, all activities undertaken by the lower beings, including movement itself, had their true origin in the spiritual world of ideas. Plato and Aristotle shared a confidence in the primary and immaterial cause of all movement, a cause that is stable and motionless.

Galileo's project mapped a cosmos in which the Aristotelian empirical grasp of reality is subject to Platonic mathematical rules. In his essay, Patočka argues that scientists of the fifteenth to seventeenth centuries, many of whom were also artists and philosophers (e.g., Leonardo da Vinci, Johannes Kepler, Nicolas Copernicus), rejected Aristotle's map of the cosmos not because of its hierarchical structure but rather because of the missing harmony within this structure. The ambition of these scholars was to prove the existence of universal harmony based on Platonic mathematics and geometry. Galileo—and later Patočka—had loftier goals than heliocentric astronomy.

Galileo intended to use exact mathematical methods to not only grasp universal harmony but also describe the process of motion. As Patočka argues, Galileo was the first thinker to understand the principles of free fall, vertical and oblique throws, and pendulum motion. Yet the new understanding of motion completely ignored the immaterial, motionless cause of movement and failed to explain whether motion originated outside of an object or within it. The cause of motion was reduced to force, the magnitude of which was the decisive factor in the initiation and intensity of the motion of any object. By replacing qualitative and quantitative relationships with the magnitude of force, Galileo abolished the ancient understanding of the cosmos by removing its hierarchy and its purpose.

The text presented below is a first English translation of Jan Patočka's essay, which provides intriguing insight into perspective on the STEM disciplines. Despite his acknowledgment of a largely positive impact of modern scientific research and the inevitable technological development in the future, Patočka's writing also contains a warning against calculated technical thought through which an individual loses own subjectivity and becomes an object object among numerous others. It seems that Patočka's prophecy coming true today in the world ruled by social media, online marketing, Internet communication, and political campaigns. The essay "Galileo Galilei and the End of the Ancient Cosmos," clearly demonstrates that Patočka's philosophical legacy remains relevant today.

[9] See for example Gadamer, H.-G. (1978). Die Idee des Guten zwischen Plato und Aristoteles. In *Griechische Philosophie III. Plato im Dialog, GW 7* (1991). Tübingen: Mohr-Siebeck, pp. 128−227.

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The detour through Comenius in our account of the beginnings of modern physics was not pointless. At the very least, it confirms the enormous change that took place in the general view on nature during the seventeenth century. This change can best be observed in the genius who stood at its origin: Galileo Galilei. Galileo too was highly concerned with the conflict between traditional Aristotelianism and the Platonic tradition, which was one of the great philosophical debates of the sixteenth century. We have seen an example of its outcome in Comenius, with the idea of pansophy, universal wisdom, universal education, and the reform of human affairs to be achieved thereby. In Galileo we encounter another epochal consequence of the same debate—the program of a systematic mathematization of physics.

The discussion between Aristotelians and Platonists at the time concerned both general philosophical issues of the essence and ultimate foundations of being and problems having to do with particular scientific disciplines: mathematics, astronomy, dynamics, etc. All, however—Platonists and Aristotelians alike—agreed in viewing the world as an ordered "cosmos," i.e., a system governed by progress from the lower to the higher, the higher being considered as the purpose of the lower that is subservient to and strives to partake of it. Beings are not mere objects, standing all on the same level; rather, they make up a "hierarchy" stretching from the grossly material to the spiritual, in which the spiritual is not only more significant but also more powerful, endowed with the capacity and significance of a directing force for the more elementary beings.

In studying this hierarchical cosmos, Aristotelians trusted as a rule what is naturally given without subjecting it to any essential reconstruction by the abstract intellect. Basically, the investigation merely systematizes and gives accuracy to the "phenomenal" world, which is thus essentially identical to the real world. Hence, immediate givenness carries in this cosmos more weight than mediated givenness; quality takes precedence over quantity; explanation is essentially inaccurate; quantitative categories are mere "accidents" of the substance, which mathematics, the science of quantities, cannot attain. This Aristotelian "empiricism" is linked with the recognition of an essential and unbridgeable difference between heaven and earth, the region of eternal lawfulness that can be grasped with geometric accuracy, and the region of approximation and contingency that cannot.

The Platonists, on the contrary, were not content with such a dual cosmos and sought radical unity. We have seen how this endeavor resulted in panharmony for Cusanus and Comenius. Sensible reality is essentially one, since it all exists by virtue of its participating in the archetypes—the Ideas. However, we cannot take this order simply from sense impressions; rather, it is something to be deciphered by our intellect, which replaces the apparent immediate order with a true order construed by itself. This true order is essentially mathematical: nature is mathematical, geometrical in character, and this is linked with the fact that the very essence of what is, the ultimate archetype according to which being is built, finds its most adequate expression in the categories of the one and the many, with their relations and combinations. Platonism is thus, in its ultimate essence, a cosmic mathematicism.

Thinkers who fought against Aristotelianism from the fifteenth to the seventeenth century—i.e., the founders of modern science: Leonardo da Vinci, Copernicus, Kepler, and many others—did not do so in the belief that the notion of a hierarchical cosmos was undemonstrable, and hence unscientific and unobjective, but rather because the Aristotelian cosmos was not unified, harmonic, and encompassing enough for them, because it was not sufficiently the cosmos it pretended to be.

The philosophical significance of Copernicus' act lay thus in proving that the Earth is no exception to the universal harmony reigning in the heavenly part of the cosmos, and that this harmony can be understood by the means employed by then-contemporary geometry: by converting irregular to regular, complex to simple figures. Copernicus showed that the compound motion by means of which the followers of Ptolemaeus explained the apparent motion of the planets around the Earth as center could be replaced by the simple motion of this assumed center around the center of the Sun. He thus satisfied two traditionally Platonic motives at once: the geometrical motive as well as the motive of the metaphysics of light, holding the center of light to be the worthiest, and therefore the eternal and immobile part of the cosmos. This Platonizing motive is yet clearer in Kepler. Kepler explicitly states that the difference between science as he himself understands it and Aristotle's science lies in that Aristotle stops at qualitative, and thus ultimate irreducible differences, whereas for him, wherever there are qualities, there are also quantities, but not vice versa.[10] True reality is "mathematical harmony," as treated, e.g., in the *Mysterium Cosmographicum*[11] or the *Harmonice Mundi*.[12] In the *Mysterium Cosmographicum*, the main role is attributed to the five regular (Platonic) solids, which focused the interest of Platonizing mathematicians since ancient times as the apex of the mathematical hierarchy: Euclid's science culminated in their study, and Kepler now makes them the fundamental law of the solar system. Historians of science like to point out that Kepler's famous three laws are but a trifling fragment among the multitude of other relations "discovered" by him thanks to his method of universal harmony, while of course paying progressively more and more attention to the factual material of astronomical observations. In short, for Kepler, the great advantage of the mathematical method, as he understands it, over Aristotelian empiricism, is that it is capable of providing reasons why things are as they are and not otherwise, on the basis of the fundamental principles of the hierarchy of mathematical concepts; the mathematical cosmos is thus, for Kepler, far more universal, more "cosmic" than the Aristotelian.

This is the context in which Galileo now places himself. His model, from the start of his career, has been the greatest of "Platonists" (mathematical students of

[10] Cf. J. Kepler, "De Quantitatibus Libelli," in *Opera omnia*, ed. Ch. Frisch, Frankfurt: Heyder & Zimmer, 1858–1871, vol. VIII-1, pp. 147 ff.—*Trans.*

[11] J. Kepler, "Prodromus Dissertationum Cosmographicum, Continens Mysterium Cosmographicum" (1596), in *Opera*, vol. I, pp. 1–214. English: *The Secret of the Universe*, trans. A. M. Duncan, New York: Abaris Books, 1981—*Trans.*

[12] J. Kepler, "Harmonices Mundi Libri V" (1619), in *Opera*, vol. V, pp. 75–493. English: *The Harmony of the World*, trans. E. J. Aiton, A. M. Duncan, J. V. Field, Philadelphia: American Philosophical Society, 1997— *Trans.*

nature): Archimedes, the founder of statics. Galileo is more ambitious: he wants to mathematize not merely the relationships of equilibrium but also those of movement. Heliocentric astronomy, of which he is the last Platonizing advocate (from his time onwards, empirical evidence then accumulates, the first proof being delivered by means of his own telescope), has taught him that all great world processes, both heavenly and earthly, are governed by one and the same unity, so that his study of mechanics has cosmic scope. This is where the meaning of mathematicism begins to take a turn: earthly things are no longer understood in accordance with the celestial (as in Copernicus), but rather celestial things in accordance with the earthly, no longer small on the basis of large, but rather, large on the basis of small. (One should mention here Galileo's sympathies for atomism to which he gave a new meaning in comparison with its sixteenth-century supporters, purging it of the Aristotelian and animistic admixtures it still retains in Sennert and Bacon of Verulam.) Galileo is the first to understand the fundamental significance of such processes as free fall, vertical and oblique throw, pendulum motion, conceived in their mathematical lawfulness. Though he was not the first to discover the law of free fall (it was already known, e.g., to the sixteenth-century Spanish scholasticist Dominic Soto, who drew his knowledge of it from the tradition of the fourteenth-century nominalists while studying in Paris), it nonetheless acquired new meaning in his hands. It is indeed likely that what first led Galileo to reflect on this law was what he had heard of scholastic traditions, given the well-nigh incomprehensible mistake he made when first attempting to formulate it in 1604 (starting from the dependence of speed on distance travelled, rather than on time)—actually a double mistake, so that the final formula for the relation between time and distance is correct. (Descartes has a quite similar error in his own initial formulation of the same law, dating from 1617 to 1619.) Since the dependence of speed on distance traveled is a formula dealt with by Albert of Saxony in his commentary on Aristotle's *Physics*,[13] frequently reprinted in the sixteenth century, one can easily assume both authors to have been influenced here by their reading of him. Yet, despite the fact that Galileo was not the first to discover this law and that his discovery was inspired by others, he does conceive it in an entirely novel spirit. He completely dissociates the law he formulates from the semi-animistic physics of "impetus," up to then the only rival to Aristotelian dynamic theories. For Galileo, there is no mysterious quality that inspirits the moving body; the change in the state of motion presupposes simply the impulse of a force, conceived of as a mere quantity in relation to other quantities. Galileo no longer focuses on the question of the inner cause ("nature") that can make a thing move in such or such a way. Clearly, he sees no answer to such questions, for example, the question of the essence of gravity, which he holds to be the source of all motion, a universal force, without which everything in the world would come to a halt; he is under no illusions as to his ability to determine the essence of this force, but neither is that his primary goal. His questioning concerns the way in which things move, e.g., the trajectory and its form, speed, acceleration, impulse, mass, etc., the elements resulting

[13] Cf. J. Buridan, *Expositio et Quæstiones in Aristotelis Physicam ad Albertum de Saxonia attributae*, ed. B. Patar, Leuven: Peeters, 1999.

from conceptual analysis of the sensible phenomenon. Once this analysis leads to clear and simple theorems allowing for mathematical deduction, a mathematical answer to all these questions, just as Euclid's elements provide answers to questions regarding the volume, area, etc., of certain geometrical forms, he is satisfied with the result. Such is Galileo's mathematicism. In the hands of this mathematical genius, the method (method of resolution and composition) gives immediate results that astound the world: not only the law of free fall, but the analysis of pendular motion, the definition of parabolic trajectories for the horizontal and oblique throw, etc., are among the most important. All of a sudden, thanks to Galileo's method, the fundamental concepts of the mechanics of solids, the main notions of dynamics as well, are freed from the heterogeneous admixtures that obscured them during the reign of the physics of the *vis impressa*. Galileo makes masterly use of them. The stage seems set for the great originator of the newly founded mathematical-physical disciplines to take them as far as Euclid in his time took Greek geometry, i.e., to found a truly systematic building of mechanics on a mathematical basis.

Yet this was not to be. A system of mechanics had to wait for Newton. Galileo did not even go so far as to explicitly formulate its basic principles, though he does go about solving concrete issues (such as the problems of projectiles, pendular motion, etc.) as if these principles were clear to him. There is, for example, no explicit formulation of the principle of inertia in his writings, and, as has been shown by A. Koyré,[14] this would have been impossible. Impossible because Galileo, in spite of everything, cannot bring himself to abandon the idea of the cosmos, the perfect world order he started off with the idea of understanding and is attempting to formulate mathematically. Impossible because he remained at heart a "Platonist." Galileo's greatest work, the *Dialogue Concerning the Two Chief World Systems*,[15] is still devoted to the problem of a world system—the same problem that stood at the center of interest for the "Platonizing" astronomers Copernicus and Kepler. Expounding in *The Assayer (Il saggiatore)* the essence of his mathematicism, Galileo speaks of the book of nature, written in geometrical figures and relations;[16] now, the book of nature is an image used by a long mystical tradition, developed among others by the Czech Comenius, one of the favorite images of the Neo-Platonic tradition. But, most important of all: Galileo, in his conception of the relativity of motion (in the Second Day of the *Dialogue*, he goes to great pains to show that a body moving along with its system behaves with respect to the system like a body at rest), cannot bring himself to give up the opinion that circular motion, i.e., the movement of the Earth around its axis or of heavenly bodies around the Sun, is a "natural," i.e., an elementary, fundamental motion. Galileo stands here in the tradition of Cusanus

[14] See A. Koyré, *Galilée et la loi d'inertie* (*Études galiléennes*, Paris: Hermann, 1939, vol. III). English: *Galileo Studies*, trans. J. Mepham, Atlantic Highlands N.J.: Humanities Press, 1978.—*Trans.*

[15] G. Galilei, *Dialogo sopra i due massimi sistemi del mondo* (1632), in *Opere*, ed. A. Favaro, vol. VII. [English: *Dialogue Concerning the Two Chief World Systems*, trans. S. Drake, New York: Modern Library, 2001.]—*Eds.*

[16] G. Galilei, *Il saggiatore* (1623), in *Opere*, vol. VI. [English in *The Controversy on the Comets of 1618*, ed. and trans. S. Drake and C. D. O'Malley, Philadelphia: University of Pennsylvania Press, 1960.]—*Eds.*

and Copernicus; he never goes so far as to formulate inertial motion along a straight line, as to consider the straight line as primary with regard to inertia. This has to do with the fact that Galileo's physics is a physics of gravity: all motion in the world comes, directly or indirectly, from gravity, so that uniform rectilinear motion is impossible; Galileo is not even capable of abstractly representing such a possibility, for a body without gravity would not be a material body (this shows a survival of the ancient distinction between mathematical and physical bodies). Motion on a plane is, in actual fact, motion on a spherical plane, and a horizontal throw is curved from the very beginning by the action of gravity. Motion in a direction tangent to the curvature of the Earth would go against the direction of gravity; the body would rise. At the beginning of the First Day of the *Dialogue*, Galileo expounds (borrowing Plato's name for his myth) that when the world was created, the heavenly bodies were dropped from a great distance toward the center of gravity, then stopped once they had gained the appropriate speed, at which they were set into uniform circular motion (Galileo never took Kepler's laws into account). Quite simply, he never questioned that his mathematical method was a contribution to the understanding of the harmonic, simple, and unified structure of a perfect, enduring, eternal, and intellectually transparent cosmos.

And yet, Galileo's accomplishment abolished this cosmos. The mathematical method, if applied consistently, does away with all "hierarchy," banishes from the world all "values," all purposes, all teleology, leveling out being as such completely: everything is equally its object. It magnifies the significance of quantities, i.e., of the categories of space and (mathematized) time. Causality is reduced to the efficient cause, and this to the occasion for applying basic mechanical laws. Everything qualitative is relegated to subjectivity (Galileo is the author of the modern version of the subjectivity of "secondary," i.e., mainly sense qualities). All in all, the "subject" becomes something that is not integrated in this mechanical world as an equal part: it becomes a mere image, a replica of objective being; knowledge of the world is a kind of pure contemplation, not an action taken within being, since the world of quality, subject, values, etc. is driven out of true, mathematical-physical reality. Its position becomes on all accounts problematic—compared, e.g., with what it was in Aristotelianism.

This fundamental transformation was rendered all the more inevitable, the more the modern idea of mathematics supplanted the ancient. Whereas ancient mathematics worked with concepts of number and figure of a so-to-speak individual nature, having their own physiognomy and "hierarchy," modern mathematics, with its emphasis on formalization and operation, took on a much more abstract character and became the proper field of modern objectivism. From the sixteenth to the seventeenth century, this process was marked by the names of Viète, Descartes, Fermat, Newton, Leibniz. With mathematics that were more and more clearly a general theory of relations, acknowledging no privileged concepts or figures, any idea of a mathematical restoration of the cosmos was of course out of the question.

Moreover, Galileo's disciples soon succeeded in overcoming the scruples of their master. Suddenly, even men of lesser ingenuity could formulate general principles of mechanics such as the law of inertia. Cavalieri had no trouble in imagining bodies without weight (infinitely distant from the "centre of gravity"). Torricelli, Gassendi, and—in a much more radical sense—Descartes were outspoken mechanicists, free of all residues of the past, and understood their master as sharing these views lock, stock, and barrel.

Yet, Galileo's lifework is a document of the way in which the endeavor at perfect unity and harmony of the cosmos, inherited from ancient times, turned into its opposite when pushed to the extreme: the Aristotelian cosmos was no more, but it took with it in its demise the cosmos itself.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

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