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On the Problem of Origin of Science: The Antiquity Context

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This academic paper provides a historical reflection on the problem of the origin of science in order to determine the reasons for differences in determining the date and content of the first scientific achievements. The application of historical-genetic research methods in the disciplinary aspect contributes to the distinction of particular scientific programs in the science body frame with a different relationship between the object and subject of cognition, the internal logic of ideas and worldviews. As a result, the existing research concerned with the conditions of knowledge function in different types of society or with the relations between the structure of knowledge and its purpose, was supplemented by an explication of forms of the continuity of program components – ontological, epistemological and axiological basis of specific scientific cognition/knowledge. In particular, it is established that the ancient world atomistic and peripatetic programs follow the structural pattern of the scientific explanation of the Pythagorean one (scientific and philosophical at the same time), contributing a new subject content in it.

Keywords: origin of science, scientific program, Platonism, Atomism, Pythagoreanism, Peripateticism, philosophy of science

INTRODUCTION

Certainly, the time of the origin of science is neither exact nor unambiguous, taking into consideration the multicomponent and dynamic nature of this phenomenon; even the symbolic date linked with the life of a particular scientist (πρώτοι ευρεται), or the founding of a scientific community would only fix the external circumstances or the consequences of the genesis of science proper. All the more so, both are open to analysis through incomplete and indirect historical documents. The historical scientific skill will consist of the reconstruction through original texts which present sporadic ancient testimonials and the integral professional *matrix*. Nowadays it provides a certain reduction of unsettling anti-scientific variety of interpretations, which is so characteristic of postmodernist historiography (Ankersmit 1989: 141) or protects such a reduction from the modernisation of ancient knowledge (Lennox 2011).

Despite the overcoming of essentialism in historiography, the insatiable need to reconstruct the genesis of science is induced by the fact that a historian of science, having elucidated the conditions of that event as reliable grounds for the possibilities of science in general, obtains the right to predict the places of 'archive deposits' of previous science, while a philosopher of science can assess the prospects of present-day scientific endeavours. Being unable to exhaust all the data empirically, both put together logically non-conflicting patterns of the *conditions* in question, among which one can distinguish the 'weak ones', that is, common for the genesis of philosophy and science, and the 'strong ones', which only pertain to science. The transition from the former to the latter within a rather brief period of time and in a limited region comprises the essence of revolutionary conceptions of the genesis of science (K. Popper, M. K. Petrov, A. I. Zaicev, S. Unguru, A. Gregory, etc.), which, by and large, tend to project to the past the new-European pattern of the scientific method formation. Following such a tracing in the past of the first sprouts of scientific thinking, the main discussions unfold around the means of analysis of its categorical and methodological self-awareness by Plato or Aristotle (Angioni 2016).

A different approach, concordant with the postmodernist one, derives both philosophy and science from the myth as a result of some relatively slow rationalisation and specialisation of knowledge (A. Comte, H. Spencer, E. B. Tylor, F. M. Cornford, B. Malinowski, A. N. Chanyshev, A. A. Gurshtein, a.o.), without contrasting it to archaic inventions and by tracing their maximum accumulation up to the formation of meaningful invariants, once brought to the specific scientific understanding. Genetic connections and the scientific status of the number in the Pythagorean and Platonic cosmology is an indispensable epicenter of attention here (Gregory 2022).

As we see it, the role of internal and external conditions relied upon in the aforementioned approaches has not been stable throughout history; they can receive feedback and change from determining factors to complicating circumstances. In particular, the social demand of effective knowledge for practical purposes can, on the one hand, stimulate the discursive formulation of causal *sequences*, but, on the other hand, it burdens them with a world-view or social-practical connotations for the preliminary recognition and further propagation (Visokolskis, Gervan 2022). The emphasis on either ones or the others – laid, within a given disciplinary field, by its own specifically scientific or socio-humanitarian historical-scientific means – can polarise researchers into 'revolutionaries' and 'evolutionists' even in the pattern of narrowing the problem of determining the starting point of *science* to its specific disciplines.

The *aim* of the present article is to establish the historically successful configurations of circumstances and forms which connect cognitive *schemes* with ancient socio-cultural *values*, proceeding from the reflecting on chiefly mathematical contents of the ancient science development given his respectability (Drekalović 2020), and to explain the discrepancies in questions and answers concerning the genesis of science on the basis of our hypothesis as to their selective heredity.

Given that the subject field of our research is the history of the philosophy of science, the basis of the methodology is the historical-genetic and hermeneutic methods necessary to identify the formation of the professional matrix of science. The method of comparative analysis is also applied to alternative concepts of scientific research programs of antiquity and 'power lines' of their development.

REVOLUTIONARY VERSIONS OF THE MATHEMATICAL GENESIS OF THEORETICAL KNOWLEDGE

In spite of modernist works of historians of mathematics, O. Neugebauer (1983) and B. L. Van der Waerden (1975) among them, on extra-utilitarian branches of the development of Eastern mathematics, quite a few historians regard them as a relapse into the tradition of Herodotus and give preference to the 'revolutionary' mathematical historiography.

Its widest known statements are based on the research of universal rational conceptual means of thinking (ἐπιστήμη), which, on the grounds of axioms and mandatory theoretical conclusions from them allowed the Greeks to embrace both their individual experience (δόξα) and the collective tradition (γνώσις) (Gregory 2005). In the worldview projection, it provided the Greeks with the discerning of the actual essence of the world and the forms of its manifestation when the known natural phenomena or socio-production situations present one of the possible displays of the general theory.

Recently, however, the Greek origin of scientific mathematics has been connected with the socio-cultural motifs of pushing aside the achievements of Egyptian and Babylonian mathematics and astrology from computational measuring assignments (τέχνη). The point is that the Greeks' famous mathematical deduction is distinguished by its concern for discerning between precise and approximate solutions of mathematical problems mainly because of the preoccupation with the unambiguous theoretical *demonstration* of those solutions (Høyrup 2012).

The conception of K. Popper (1995) presents the final result of the reshaping of knowledge as an impact of active international trade and ancient Greeks' colonial habitation, which demystified the customs of their native metropolis, placing them alongside alien or new customs as their part. Similar epistemologisation occurred with professional prescriptions, which generated universal principles pertaining to crafts, their articulation methods and performers, and also with legal social statuses, which could be perceived in political argumentation and logical substantiation of law as a general reason for the variety of specific political interests.

The aforementioned epistemologisation looks particularly contrasting in the light of sacral or functional experience in astronomy, irrigation, trade, and construction borrowed from Ancient East and put under the axiological aegis ἀρχή – the monistic foundation of nature. It only took a few generations for the Greeks to pass from age-old observation tables and problem-solution specimens to proving theorems and formal rules of operating the received ideal objects through abstracting and generalising the symbols and through causal regulation of those specimens. 'Greek mathematics presents the historian, for the first time, with a mathematical culture that we recognize as ours. It is not a culture of approximation, empirical calculations accompanied occasionally by a verification of the results, innocent of generalization, abstraction, and proof. On the contrary! Whereas Egyptian and Babylonian mathematics consists of specific exercises, attended sometimes by verification of the results, but never by any attempt to justify the method employed, Greek mathematics, from its beginnings in the sixth century BC, displays a quest for general propositions, demonstrated rigorously and, therefore, persuasive beyond reasonable doubt' (Unguru 2018: 22–23).

This can be conducive to the *impression* that a pattern of the method and result of such (re)organisation of knowledge was actually determined by mathematics, which is illustrated by its etymology (μάθημα – 'something to be learned', 'science') and purely Greek terminology of the new mathematics (with the exception of 'pyramid'), confirmed by the first (V–IV centuries BC) scientific *theories* (Archytas' proportions and divisibility of whole numbers, Eudoxus' ratios, Theaetetus' quadratic irrational values) and crowned with Euclid's '*Elements*' (their deductive axiomatic structure was later accepted by I. Newton for classical mechanics and J. Neumann for quantum mechanics). 'The great beauty of Euclid's geometry was that if you agreed with the definitions, postulates and axioms, then the proofs compelled you to believe the more complex theorems. For one science at least, here was a definitive procedure for resolving disputes and making progress' (Gregory 2001: 41).

In contrast, natural sciences and liberal arts, because of the insufficient differentiation of knowledge and the burdening need of interpretations, *look* but a chain of empirical regularities regarded as inferior because they do not reach the utmost conditions of the existence of objects, do not embrace contradictory specimens and do not bring in creative predictions.

However, in addition to the traditional exaggeration of the credibility of the mathematical form of explanation (Drekalović 2020) this retrospective is selective and restricted by the examination of Plato's and Pythagoras' teaching which bound together mathematical and philosophical systems as unique instruments for the deductive obtaining of reliable knowledge.

THE FORMATION OF PLATONIAN-PYTHAGOREAN PROGRAM OF SCIENCE

According to the influential Aristotelian interpretation, Platonism and Pythagoreanism counter-opposed the essentially quantitative cosmic definiteness of things to the preceding *qualitative* one, by connecting the former with the initial order of super-global and human mind. In the beginning, if not the mythological Prometheus, then the legendary Pythagoras declared the numbers to be the 'masters of things', or, in other words, the ontological essence of the world; they, as indivisible entities, formed spatially extensive bodies (arithmetisation of geometry), while numerical ratios could directly express the cosmic connection, which was confirmed by the 'mathematical quadrivium' (music, arithmetic, geometry and astronomy). The generalisation of those ratios and the deductive derivation of their transformations laid the foundation of arithmetic and geometry of that time and, eventually, entered Euclid's '*Elements*' which was composed of 7 books. However, beyond mathematics (in architecture, psychology, ethics, etc.), explanations were basically reduced to establishing the *structural* identity (isomorphism) of material and mathematical expediences – without logical proofs, inferring an empirical ascertainment.

The discovery, in the second half of the Vth century BC, of the incommensurability of the diagonal of the square with its side and other (cor)relations which were not expressed with the only known (at that time) integral positive numbers was conducive to the crisis of the program. Zeno of Elea, in particular, demonstrated in his aporias the dubiousness of Pythagorean interpretation of the straight line as an endless multitude of sizeless units, while young Plato, who was known for his Pythagorean inclinations, started regarding numbers as one of the ways of the ideal expression of things rather than their ultimate essence.

The Pythagoreans themselves, however, initiated the replacement of arithmetical mathematics with geometrical mathematics in which values are expressed not by the points but by segments and rectangles which enabled to correlate not only rational but also irrational numbers and segments (Theodorus of Cyrene, Hippasus of Metapontum). In that fashion, the geometrical theory of proportions was developed, which, even if it was not revolutionarily transformed later into a kind of geometrical algebra, drew, at least, a dividing line between geometry and arithmetic.

In the aforementioned peripeteia, the number became a self-sustained goal (object) and trained the second generation of Pythagoras' followers to agree precisely on the initial preconditions which could rigorously derive the rest of knowledge (the axiomatic method of Eudoxus of Cnidus.) The Pythagoreans also initiated, on that basis, the scientific approach in other areas (Archytas in optics and mechanics, Menestor Sybarita in botany, Hippasus in physical experimentation, and partly Alcmaeon of Croton in medicine).

Since then, science personified by the Pythagoreans was concerned with the double goal of cognising the natural being and simultaneous reflecting the credibility of their own methods, which, in Hellenistic times, was to find its manifestation in the 'original and unparalleled theory of the criterion of being, which involves a complex criterial apparatus for knowledge-acquisition, involving a subject of judgement, and object of judgement, and a paradigm or standard by which to produce the judgement' (De Cesaris 2018: 224).

Solving, in his later life, the crisis of the Pythagoreans' (and, partially, the atomists') arithmetical theory of nature, Plato in '*Timaeus*' (and, partially, in '*Parmenides*') set up the credibility of knowledge on the speculative explanation of the geometrical structure of the matter. Using numerical series that partially imitate the musical scales of the Pythagoreans on the common idea of harmony, Plato developed mathematical cosmogony, according to which the world was based on mathematical structures rather than physical objects. The former, however, could not embrace, at the time, the observed irregularities in the planet movement, and it encouraged the idea of the existence of more fundamental reasons for celestial movements (πάντως ἀπλανεῖς) (Gregory 2022). '"Saving the phenomena" was in some sense the main goal of all Platonic philosophy: to discover the eternal behind the temporal, to know the truth hidden within the apparent, to glimpse the absolute Ideas that reign supreme behind and within the flux of the empirical world' (Tarnas 1993: 53). That is why, unlike the Pythagoreans, Plato's mathematics does not manifest the ontological uniformity of the world but serves as a language superposed upon visible phenomena.

At the same time, that superposition was restricted by *natural* limits (that is why, for instance, mechanics as a useful art of material embodiment of what does not occur naturally was not subject to mathematisation) and due to the differences between static ideas and dynamic natural bodies it was of little use for natural sciences beyond that program.

UNIFICATION OF MATERIAL CHARACTERISTICS IN THE ATOMISTIC PROGRAM OF SCIENCE

The obstacle for the consolidation of Pythagorean and Platonic teaching as a universal program of ancient science was detected on the most general level of categorical controversies of the early Greek philosophy (being/non-being, existence/origination, numbers and divisibiles/characteristics) which conditioned the problem of conceptual self-identity of a changeable object.

The founders of atomism Leucippus and Democritus of Abdera found a common denominator for the two extreme expressions of that problem, one being the Ephesus permanent movement, the other being the Eleatic solidified homogeneity of being; that common denominator was, in all probability, borrowed from the Pythagorean arithmetisation of geometry: if everything is composed of rationally commensurable parts, the being is, to some extent, divisible.

On the other hand, atomists transfer to a more abstract level than early Greek physicists with their analogies of naturalistic elements: water, air, fire and earth are now only distinguished by the size and form of the surface of universal indivisible particles (ἄτομος, ἀμερὴ).

As the actual 'initial source' of things, those particles of matter, distance and time (as well as isotropic vacuum and the laws of movement) cannot be perceived sensually, while their theoretical structure corresponds to the empiric characteristics of the matter – number, form, impenetrability, extension and *weight*. The latter force serves as a common cosmogonic substitution for a multitude of material characteristics: different weight of particles → different velocities → collisions → vortexes → grouping by likeness (via compression, thickening, dilution, unification, disintegration and dissolution) with the eventual spontaneous formation of the geocentric system of the real world in our part of the endless emptiness. In this fashion, nothing originates from non-existence or goes to nowhere; even disappearance is just the disintegration into particles as small as atoms. So, if the subject of Platonic-Pythagorean program was a ratio, the atomistic one centered on movement as the hustling ('the closest reasons') of the point being, in the cohesion of which the being does not belong to the whole, it belongs to an atom – one or another. It is because of this definition that the explanation (αιτιολογιαν) in atomism looks so awkward that Democritus found it superior over the throne of Persia (Diels 1959: 166).

However, in their concern about the axiological opposition to the willfulness of the fate of purely natural (i.e. devoid of any expediency) forces of the cosmogonic process, atomists come to a '*figurative*' methodology: if speculative 'initial sources' can determine the whole variety of being through the visible 'closest reasons' for their spatial redistribution (the atoms' own position and their mutual apposition), the true cognition is available in completed and universally significant miscellany of soul atoms. The qualitative homogeneity of particles makes it possible to reduce the comparison of things ('the form of their porosity', according to Strato of Lampsacus), to proportional ratios of the weight values of their components.

CONTINUALISM, ESSENTIALISM AND QUALITATIVISM OF THE PERIPATETIC PROGRAM

The peripatetic program was formed in Aristotle's philosophy as a compromise between the two previous programs which proceeded from the value of discreteness. In other words, both the mathematical and atomistic programs proceeded from the notion of the indivisible, with the only difference that the Pythagorean 'monad' as the core of all numbers was ideal and sizeless (that is why its Platonian geometrical analogue, the triangular quantum of space, was also indivisible), while Democritus' 'atom' as the core of all bodies presented the precondition for mathematical structures (that is why, according to Antiphon, all segments were composed of a completed number of particles, which settled the Pythagorean problem of incommensurable quantities).

Being an opponent of Plato, Aristotle sought to give an integral comprehension of the cosmos, accumulating, at the same time, the *empiric* knowledge of specific branches of science with their own subject and method. Contrary to Platonism, this experience is not regarded as something wrong; it is just insufficient, which can be managed by a correct interpretation, when the comprehension of the whole forms the basis for the examination of the partial. According to Aristotle, this whole – unique and self-identical – is the primary essence (οὐσία), distributed in a multitude of sensually various individuals. It is primary in every respect: by definition, by cognition and in time (Aristotle 1933: 311–313).

In this way *essentialism* was established – the principle of primacy of the concept over its relations, as a logical subject over divergent predicates and, consequently, the prohibition to define a notion through its opposite (the law of non-contradiction), since the essence expressed by a notion can only have contradictory characteristics in the potential state – before one of them is actualised as essential. In this fashion, the Platonian dialectics which allowed for those opposites, proved to have involved the ambiguity and infinity of the obsolete pre-Socratic chaotic material primary source and, as such, was disqualified by Aristotle from great science, one of the new methodological consequences of it becoming the objective *specialisation* of knowledge – attributive for the further definition of science. The initially integral ἐπιστήμη was divided into practical, productive and theoretical kinds by Aristotle (Zhmud 2020: 274).

Contrary to the priority of quantitative structures of Plato's 'Timaeus', Aristotle's 'nature' has reasons in itself and, therefore, is dual: unchanged essences (described according to a formal reason) have potential correspondences in their manifestations within a movable empirical visibility (described according to a material, acting and purpose-oriented reason). The former presents the goal of science, while the latter its means. Although in the corresponding classification of sciences physics and mathematics are related to theoretical sciences as diversified, if equal, approaches towards one and the same object, Aristotle's mathematics is but an auxiliary science in the cognition of nature. Its visual geometrical language, which was of little use for calculations, gave every reason to think that it digressed, in its quantitative idealisations of sense reality, from the essential qualitative characteristics of movement (qualitativism). The astronomy of 'coelosphere', however, can be regarded as applied geometry, quite in the Platonian way.

THE CRISIS OF SCIENTIFIC HEURISTICS AND THE FORMATION OF THE INNOVATIVE TYPE OF SCIENCE

While the aforementioned programs were developing methods that were subject to unbiased translation, science, harmfully for its own self, kept moving away from philosophy and its academic schools: 'starting in the third century, the few astronomers, mathematicians, natural historians, and geographers who worked mainly in Alexandria were completely isolated from any general intellectual or educational movement. They were advisers on military matters (Archimedes), astrologers, or simply parts of the entourage of the court' (Ben-David 1971: 40). As a result, natural explanatory causes became less and less interesting for scientists and yielded to the instrumental techniques of calculation and anticipation of phenomena under study (σοξειν ta φαινόμενα) (Koyre 1955).

The thing is that classical ancient Greek philosophy provided scientific initiatives with the conceptual conviction of the *a priori* rationality and cognoscibility of cosmos, which embraced even Plato's 'matter' and its corresponding 'lusty' part of human soul (Salles 2018). The latter, as not being subject to the rational control and cognition, were considered, ontologically, to be inferior to divine *elements* which lend the sophisticated and beautiful regularity to nature (Lehoux 2019). When mass consciousness received a mystic irrational guideline from Oriental cults and the scientific community accepted exoteric models of Neo-Platonism and Neo-Pythagoreanism, scientific achievements, moving farther away from utilitarian calculations and supplements, on the one hand, and from rational reasons, on the other hand, turned into training courses composed of compilations and paraphrases.

However, as the Alexandria Museum exemplifies, this required meticulous work with texts (cataloging, commenting, comparative analysis, etc.), which, eventually, laid the foundation of specialised philological methods and the abstract part of the universal scheme of scientific cognition. But it was not until the late Middle Ages that prominent scientists (R. Bacon, Robert Grosseteste a.o.) got converted from authoritarian tales to an essentially new content in the form of an imaginary experiment or some sensual natural experience, which, according to P. Duhem, K. Jaspers, A. C. Crombie, S. L. Jaki a.o., presented the aspect of contemporary science for the first time.

The situation changed essentially only after the overcoming of the initial directive ἐπιστήμη ('knowledge for the sake of knowledge'), which engendered both philosophy and science in the classical antiquity, in favour of the directive τέχνη ('knowledge for the sake of benefit and supremacy'), which was actualised owing to hermetism.

Not until the traditional personality's 'ability to judge' got accustomed to enterprising ad-hoc explanations, had scientific programs combined in their explanans structural and causal components which were separated by the ontological and disciplinary dichotomy of the celestial and earthly worlds. Only 'hybrids' existed, such as Ptolemaic *cosmology*, which, according to I. Lakatos's scientific research programs, combined the 'nucleus' of Aristotelianism with the 'protective belt' of Platonian and Pythagorean astronomic theories (Philolaus, Eudoxus, Apollonius, Hipparchus, Aristarchus of Samos). Reconciling the contradictions of ontological axioms and observation data, it became overgrown with interpretations of the circular movement of celestial bodies (excenters, trims, equants and epicycles), until N. Copernicus discovered the way of their reduction through substituting Aristarchus' heliocentrism for Aristotelian geocentrism in the 'nucleus' of the program. Although it was provided, in the short perspective, with the ability to predict new facts (the phases of Venus, star parallax, etc), the relay race of classical scientific programs (Cartesian, Newtonian and Leibnezian) was only initiated after the merging of Aristotelian causal schemes (formal, purpose-oriented, material and acting causes) and atomism (the closest empirical and theoretical initial causes), which was conducive to the elimination of qualitative restrictions of nature and the possibility of mutual 'translation' of empirical-experimental generalisations and theoretical analysis in the new nomological scheme of scientific explanation (Lakatos 1999: 48–52).

CONCLUSIONS

While the *criterion* approach to the definition of science implies the chronological definition of the genesis of science when the chosen starting point combines a set of characteristics of the present-day definition of science and the first exactly known scientific event, the *reflexion* approach requires to address not only to cognitive, but also to institutional, spiritual, cultural and social-economic prerequisites – by means of history of science, sociology of science, etc. Embracing science matrix as a whole – in the unity of aspects of knowledge, methodology and the social forms of its organisation – makes it possible to systematise its reasons, not just enumerate the borderline criteria of scientism, thus rationalising its goals and values, alongside results or means.

The choice of competing scientific programs, conceptually grounded in the works of I. Lakatos, enables us to represent the mutual conditionality of *sociocultural* and *intellectual* heredity in the development of science as a starting point and a unit of the historical dimension of science. In this respect, the answer to the question about the conditions of possibility of the genesis of science demonstrates, together with the necessity for a specific scientific ability to derive knowledge in the extra-utilitarian and extra-empirical way (in the abstract ratios of explanans and explanandum) and to carry into effect the transition between the levels of knowledge from particular phenomena to a law, a theory and general ontological, epistemological and axiological ideas.

The discovery of the quantitative mathematical version of those ratios in the first ancient scientific programs laid the foundation of expediently and systematically organised *knowledge* which later became the means to form other disciplinary principles. The latter, by differentiating, step by step and according to a historically new subject, the object, the method or the task, generated other academic modes: science as a specific *activity* and social *institution*.

In our opinion, the concern with the selective heredity of the indicated 'conditions of possibility,' the program connections between the levels of knowledge as well as academic modes, enables us to meet the urgent need of conceptual reflection of science beyond the existing *opposition* of the essentialism of macro-historical structures and the relativity of micro-historical situations with its continual derivative antitheses of science and myth, revolution and evolution, knowledge and life, activities and social institutions, which refer to incommensurate dates and causes of the origin of science.

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Apie mokslo kilmės problemą: antikos kontekstas

Santrauka

Straipsnyje pateikiamas istorinis mokslo kilmės problemos apmąstymas, siekiant išsiaiškinti, kodėl skiriasi pirmųjų mokslo pasiekimų data ir turinys. Istorinių genetinių tyrimo metodų taikymas disciplinų požiūriu prisideda prie konkrečių mokslinių programų išskyrimo mokslo korpuse, kai kalbama apie skirtingą pažinimo objekto ir subjekto santykį, vidinę idėjų logiką ir pasaulėžiūrą. Todėl esami tyrimai, susiję su žinių funkcionavimo sąlygomis visuomenėse ar skirtingais žinių struktūros ir jų paskirties ryšiais, buvo papildyti ontologinėmis, epistemologinėmis ir specifinio mokslinio pažinimo bei žinių aksiologinėmis prieigomis. Nustatyta, kad antikinio pasaulio atomistinės ir peripatetinės programos vadovavosi pitagoriškojo (kartu mokslinio ir filosofinio) mokslinio aiškinimo struktūriniu modeliu, papildydamos jį nauju dalykiniu turiniu.

Raktažodžiai: mokslo kilmė, mokslinė programa, platonizmas, atomizmas, pitagorizmas, peripatetizmas, mokslo filosofija