

The cosmic system of the pre-Socratic philosopher Anaximenes and stars and their formation

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Abstract. In the paper is presented Anaximenes theory of air as the initial cause of nature which is transcendental. We examine Anaximenes account on the formation of Earth and stars, which is based on the accumulations and "thinning" of the primal substance, and discuss some similar characteristics with the scientific theory of star formation, while the philosopher's reference to the fiery nature of stars reflects the theories of energy production in their interior.

Key words: History of Astronomy, Anaximenes, Star formation

Introduction

The pre-Socratic period of Greek philosophy was undoubtedly the first major landmark in the history of philosophy and science; then for the first time the human intellect attempted to explain natural phenomena based on the relation between cause and effect. Pioneers in this attempt were the philosophers of Miletus, Thales, Anaximander and Anaximenes, who, in their effort to explain the origins of the world, expressed interesting astronomical views, which sometimes have similarities with results of modern science. In this work we study the role of "air" (the one of the four elements) in the creation of the world according to Anaximenes, through its accumulations and "thinning". We also discuss some similarities of the mechanism described by Anaximenes with the theory of star formation, as well as the philosopher's reference to the fiery nature of stars reflecting the concept of the energy production in their interior.

1. Wind as a cosmological principle

The cosmological system proposed by Anaximenes is based on the views of the two other philosophers of the so-called Milesian School, Thales and Anaximander, who suggest that the Universe was created on the basis of a primal element, *water* and *apeiron* (infinity?), respectively. According to Anaximenes, *the underlying nature is one. However, Anaximenes did not consider it as indefinite as he [Anaximander] did, but definite, calling it "air". The air varies with respect to its density and thinness, depending on the substances* (Simplicius, In *Aristotelis Physicorum*, 24, 26-29). Thus, contrary to Anaximander, who theorized that *apeiron* is not a subject for determinations, Anaximenes stated that the primal element of the Universe should be close to the property of *incorporeal*, while at the same time it

is infinite and never perishes. These properties point to the transcendental nature of "air" (Olympiodorus, *De Arte Sacra*, 25, B3) along with the fact that air as a cosmological principle including everything and could also exceed without limits (Kirk, et al. 1988: 154). What is very interesting in this case is the fact that Anaximenes (just like Thales and Anaximander) accepted the idea of existence of an initial substratum which is an aspect of philosophical monism according to which there is only one initial cause of the Universe. This theory of Anaximenes influenced other scholars such as Diogenes of Apollonia (5th cen. B.C.) who considered air as the basis of creation and perishing of every creature in the Universe (Simplicius In *Aristotelis Physicorum*, 151, 31). This idea was also accepted by Aristotle who supported the view that the initial substratum (matter) is unformed and then can be transformed in every possible way (Aristotle, *Physicorum* 192a, 31).

The nature of air is, according to Anaximenes, infinite; from it originate all that was ever born and will be born, and also gods themselves. Subsequently, from the primal substance originate all beings and the world. However, its nature is not apparent when it is uniformly distributed (*homalotos*) and becomes visible only along with cold, heat, humidity and motion, concepts that possess the properties of accumulation and thinning (rarefaction). Thinning creates the element of fire, while from the accumulation result phenomena such as the clouds, while the elements of water and earth are also created. In the cases of dense accumulations stones are produced (Hippolytus, *Refutatio*, I, 7, 1). Apparently all Presocratic philosophers had made observations of the physical world. Although Kirk, Raven and Schofield (1988: 155) support the view that Anaximenes was the only Presocratic philosopher who explained every change in the physical world based on the existence of a unique substance. Also Plato argued that rarefaction and condensation of the initial element results in the creation of other elements like fire, water and physical phenomena such as clouds and fog (Plato, *Timaeus*, 49b–50c)

What is important in this context is that the basic essence of the Universe is originally non-perceivable by the senses, while through motion becomes visible because of the creation of elements and natural phenomena it causes. Even concepts as warm or cold are phenomena of matter caused by accumulations and rarefactions (Plutarch, *De Primo Frigido*, 7, 947 f (DK 13 b1.)). His characterization of "air" as divine, and as an essence that permeates all the elements and bodies, proves the superiority of its nature with respect to the other elements of the Universe (Aetius, *De Plac.* I, 7, 3). Hence, its cosmological role is not limited to the creation of the beings, but it extends to their cohesion, exactly as the soul "holds together" (contains) the body (Aetius, *De Plac.* I, 3, 4 (Diels 278)). It is obvious that according to Anaximenes thought the nature of air is correlated to that of the soul because both are incorporeal. In this context the origin of the world is attributed to an element the nature of which is superior to the other elements of nature.

It is clear that the properties attributed to air by Anaximenes set it as the primal cosmological principle; in this way, Anaximenes adopts the principle of mechanical causality (Niarchos 2008: 84), since the motions

of the air are the cause of the creation of beings. This process is of great importance for the creation of the stars and the Earth.

2. The nature of celestial bodies according to Anaximenes

Anaximenes supports the view that the celestial bodies originate from earth and, more specifically, *from the evaporations that come from it, when these evaporations rarefy, fire is produced, and from that fire, which ascends, stars are produced* (Hippolytus, *Refutatio*, I, 7, 5). It follows that the earth has been formed from the condensation of the original air (without any mention about its original cause); then, evaporations are produced, which, due to the rarefaction, form the fire of which stars consist (Kirk et al. 2001: 160).

He believed that the Earth is flat and motionless (Aristotle, *De Caelo*, 294 b 13), that the Sun is also flat like a leaf (Aetius, *De Plac.* II, 22, 1), while the stars revolve around the Earth. At the same time, he argued that the Sun sets because it hides behind higher parts of the Earth and its distance from the Earth increases (Hippolytus, *Refutatio*, I, 7, 6). Nevertheless, in his work there are also astronomical elements similarly to the modern scientific views. Specifically, he suggests that the nature of the stars is fiery and that they coexist with bodies that revolve along with them but are invisible (Aetius, *De Plac.* II, 13, 10). This intuitive description given by Anaximenes is compatible to the existence of planetary systems, in which planets, invisible to us, orbit their stars. Today a large number of such extrasolar planets, which indeed revolve around other stars is discovered. Additionally, many thousands of binary star systems have been discovered, which move around their common centers of mass, with the fainter star of the system (the *companion*) being invisible in many cases. A nearby characteristic example is Sirius or Alpha Canis Majoris, whose irregularities in proper motion were attributed by Bessel (1844) to an invisible celestial body that is now known to be a white dwarf (Sirius B), which is 8,000 times fainter than the *primary* star (Sirius A) because of its tiny size and which was discovered in 1862. Also his reference to the fiery nature of stars is compatible to modern astrophysics from which we know that stars are luminous spheres of plasma which shine by turning hydrogen into helium.

Pertaining to the composition of stars, Anaximenes supports the view that the Earth was produced by the condensation of the initial element of "air", while the Sun, the Moon and the other celestial bodies originated from the Earth. Anaximenes claims that the Sun is similar to the Earth and becomes very hot because of its very fast movement (Plutarch, *Fragmenta* 179, 39 (DK 13 a 6)).

These views of Anaximenes show that philosophers not only dealt with astronomy, trying to calculate the orbits of celestial bodies in the sky, but also tried to explain the nature of stars. This is particularly significant as it marks the passing from astronomy to astrophysics. Even nowadays science is not only limited to the observation of celestial bodies thanks to applications such as spectroscopy and modern instruments like space telescopes, we are able to study stars galaxies and quasars million light years away from our planet.

Conclusion

According to the Greek philosopher Anaximenes, the formation of the Earth and the stars was caused by the condensation of the primal substance. To-day it is known that, immediately after the Big Bang, the primal material of the Universe was created, in the form of diffuse gas consisting of hydrogen and helium and traces of lithium atoms. Because of accumulation of matter, gravitational forces and nuclear reactions inside these gaseous clouds, protostars were created, followed by the stars and the planets, such as Earth. Moreover, the reference by Anaximenes to the fiery nature of stars is essentially a first attempt to explain their true nature. As it is known today, star formation is influenced by radiation and the rotation of their total mass, while their sources of energy are basically nuclear fusion reactions. The condensation of the original nebula, which consists mostly of light elements, to the protostar stage and the production of radiation through heat, which prevents the gravitational collapse of the star, lead to the creation of heavier chemical elements, which continue to be produced during the star's lifetime through nucleosynthesis nuclear reactions.

As one can see, Anaximenes tried to understand and explain the star formation and its nature without mythology and deities and some of his intuitive conclusions as the formation of stars by condensation of primal matter and its fiery nature are not inconsistent with modern scientific views.

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