

The Cosmological Theories of the Atomic Philosophers, the forerunners of Quantum Physics, Astrophysics and Cosmology

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Abstract

The aim of the present work is the study of Leucippus' and Democritus' cosmological theories for the atoms, the vacuum and the creation of worlds comparing to the principles of Quantum Physics, Astrophysics and to cosmological theories of modern Cosmology.

Keywords: atoms, vacuum, quantum physics, inflation, Democritus.

1. Introduction

In ancient Greek world, philosophy and scientific research were mainly affected by the Pre-Socratic philosophers, who searched for the origin of the world. The Pre-Socratic natural philosophers studied the nature mechanisms so as to determine the causes of the natural phenomena, making thereby cosmology an integral part of philosophy. The cosmological search of the Greek philosophers pointed to determining the primary substance that the world was created from. Many ancient philosophers asserted that a First Principle created the world; Thales of Miletus called this first principle water, Anaximenes air, Anaximander apeiron (boundless) and Heraclitus fire respectively. Other philosophers argued that the First Principle was not unique and there were more than one principle; Anaxagoras called the ultimate principles of things Cosmic mind (Nous) and claimed the existence of infinite material substances called homeomerias. The Pythagoreans believed that the universe was formed by the harmonies consisted from numbers and governed by mathematical relations.

However, the Atomic philosophers of the 5th century played the most decisive role in indentifying the first principle of the world. The philosophers Leucippus and Democritus argued that atoms were the basic units of all the things of the world. As a result, the fundamental principles of the modern Atomic Theory, which played a crucial role in the research field of Cosmology, had already been set.

2. The Atoms, the Vacuum and Modern Physics Research

Leucippus and Democritus innovated with respect to the other Pre-Socratic philosophers and proposed a new philosophically theory. They did not believe that fire, air, water or land were the ultimate substances of the world, but the atoms and the void or in other words the being and the non-being respectively. The being is full and solid; not being is empty and sparse. It is said that the vacuum exists as long as the body exists; thus the non-being exists as long as the being exists. These two are the material causes of the existence of the things (Aristotle, *Metaphysics*, 985, b 4-10). In addition, the vacuum is characterized as *meden* or *ouden* which in ancient Greek means nothing.

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In comparison to the philosophers of Eleatic school who believed that the non-being and nothingness have absolutely the same meaning, the Atomic philosophers believe that the non-being exists as vacuum, which is different from the vacuum that exists in the atoms. Moreover, according to Theophilus Veikos, the vacuum appears with a negative meaning; as it exists everywhere there are no atoms (Veikos, 1985). In fact the vacuum separates the atoms; thus the vacuum contributes to the constant motion of atoms (Simplicius, In *Physicorum*, 28.4) and subsequently to the creation of worlds.

Furthermore, Leucippus and Democritus stated that there are an infinite number of principles called atoms, which means in ancient Greek “indivisible. Atoms are also apathetic since there is no vacuum inside them, as the division is caused due to the existence of the vacuum that exists in bodies (Simplicius, In *De Caelo*, 242, 18-21). Leucippus and Democritus were also aware that there must be a final limit for every being’s division; hence the philosophers refer to atoms (matter that cannot be further divided) which are compact and infinite in the number. Furthermore, the atoms have also another property, called apathy, since their properties never change (Galen, *De Elementis*, 419.1). So, the fundamental forms of the nature consist of elements that are not undergoing any external influence; they are only moving due to the vacuum. Therefore the fact that atoms are apathetic is an important argument in favor of their indivisibility.

In addition, according to Democritus atoms are of the same nature (Simplicius, In *De Caelo*, 569, 5) and have common properties. However, atoms are different in the shape, the order and the position. Thus, the letter A differs from N in shape; AN differ from NA in order and Z differs from N in position (Aristotle, *Metaphysica*, 985 b, 13-17). From this quote it is clear that an atom is different from another in shape, in order and in position. Consequently, even the differences of objects perceived by humans are actually a result of the different combinations of basic structural elements.

The Atomic philosophers have decisively contributed to the development of natural science; especially to the branch of quantum physics. The philosophers formulated theories for the atoms, the smallest part of matter; quantum physics states that the elementary particles are the smallest parts of matter and they cannot be further analyzed. However, human senses cannot determine the real nature of the elementary particles because they exhibit a wave-particle duality (Hodson et al., 1997). The particle-like behavior was studied by the German physicist Max Planck (Nobel Prize, 1918), who observed the energy distribution of a black body (Abro, pp. 447). The wave-like behavior was studied by the Dane physicist Niels Bohr (Nobel Prize, 1922). He studied the structure of the atomic nucleus and stated that the electron is trapped in energy levels and orbits and it does not emit radiation (Abro, pp. 490-491). Furthermore, Count Louis de Broglie (Nobel Prize, 1929) proposed the wave-like nature of the electron (Abro, 1951). The year 1927 is a landmark in the history of quantum mechanics because Werner Heisenberg (Nobel Prize, 1932) published the uncertainty principle (Heisenberg, 1949); thus the position and the velocity (or the momentum) of a particle cannot be measured at the same time. The human senses cannot perceive the nature of matter while particle accelerators can. Finally, the Standard Model was proposed so as to explain how the basic building blocks of matter interact, governed by four fundamental forces (Novaes, 2000).

However, concerning the meaning of the word “atom” there is a significant difference between modern physics theory and Atomic philosophers teaching. Leucippus and Democritus believed that atoms cannot be further divided. Modern science has accepted this terminology, but as it turned out the atoms are not indivisible and they consist of subatomic particles and especially of protons and neutrons that make up the nucleus and of electrons orbiting around it. Even though these particles are not the smallest structures of matter, protons and neutrons both consist of three quarks (Hey & Walters, 2005). Consequently, the word “atom” refers to the fundamental forms of matter, which would not be analyzed further.

3. *The cosmology of Atomic philosophers*

Leucippus was the first philosopher to describe the cosmological system of Atomic Philosophers. According to Leucippus from the atoms and the vacuum many worlds are created when many bodies of any shape are moving from infinity into the large vacuum, where their accumulation produces a vortex, due to which they conflict with others and are rotated in any way; they begin to separate and some parts come closer. When they balance because of their large number, they can no longer be rotated; then the thin bodies are ejected outwards in the vacuum, while the others are not kept together and approach one another while at the same time are interlaced and they initially form a spheroid system. From this system a hymen is detached which includes various bodies. As swirling due to the centrifugal force, the hymen becomes thin because bodies close to the vortex always flock (towards the center). Thus the earth is created; the atoms that are swept away towards the center are finally joined. The surrounding hymen increases and drags the bodies which come from the outside. As they are swept by the vortex the hymen incorporates only these bodies which come in touch with the hymen. Some of these come together and form initially a very wet and muddy system, while they rotate with the whole vortex they become dry and then ignite; creating the nature of stars (Diogenes Laertius, Vitae, IX, 31-32). Thus, the creation of worlds is described in the following stages: a) vacuums are created; atoms drop into them, b) vortex and c) creation of the hymen. At this point, we are going to study more carefully all these steps.

a) As we discussed above, before the creation of the world the first universal substratum exists in two situations (the full and the vacuum), which are not perceivable by humans. Later on, except from the large initial vacuum, other smaller vacuums are created. The atoms, which come apart from the first vacuum, drop into the smaller vacuums, due to disparity and other differences that they have (Simplicius, In De Caelo, 294, 33-35). Since the differences of atoms appear in size and shape, then the system which is formed by the other atoms force the first atoms to move towards the secondary vacuums which correspond to other worlds. Perhaps in some of these worlds there is neither Sun nor Moon; while in some others these two celestial bodies are larger or smaller than they are in our own world. (Hippolytus, Refutatio I, 13). It is clearly mentioned that the Atomic philosophers support the possibility of the existence of many worlds different from our own world.

Leucippus and Democritus strongly believed that two different types of vacuum are necessary for the creation of the worlds. The atoms move into the space formed by the one type of vacuum (the first vacuum), while the other type of vacuum contributes to the aggregation of the atoms. According to modern Inflationary Cosmology from the initial state of the false vacuum many new real vacuums are created, which due to their interaction with the Higgs field evolve into different worlds (Theodossiou & Danezis, 1999). According to Andrei Linde's theory (1981) if the universe is considered as a homogeneous bubble, any disturbance within creates a new bubble and the world (bubble) evolves as a fractal of the early universe (Theodossiou & Danezis, 1999). It is astonishing that Leucippus' and Democritus' cosmological theories conceptually coincide with modern scientific research. The vacuum is not considered as an empty and without meaning space but as an area (non perceptible to the senses) which is very active and contributes to the creation and development of the world.

b) The formation of the vortex is the result of the detachment of atoms from the infinity (Simplicius, In Physicorum, 327, 24) and their fall and accumulation into the large created vacuums. However, in order the bodies to be clasped a mechanical hit force is required (Aetius, De Placitis, I 4.2) which condenses the bodies, while producing a circular motion that causes the unification of the same bodies. Once equilibrium is reached between them the rotation stops, the thin bodies are moved away, while the rest of them remain united and form a spheroid system (Diogenes Laertius, Vitae, 9, 30). Using the terminology of Chaos Theory, we could say that the spheroid system is actually an attractor and the whole system of the bodies tends asymptotically to it (Stewart, 1998).

It is important to note here that the spherical condensation created by the presence of a large number of bodies, refers to the creation of a gravitational field caused by the accumulation of a large amount of matter in a point in space. At this point the forces are too strong to create stars or even black holes. In a similar way the Solar System created, which gradually evolved from a gas cloud that collapsed under gravity and turbulence, resulting in the creation of the Sun and the planets. Even the spiral shape of our Milky Way indicates that the matter, from which it consists of, performs a rotational motion, resulting in the accumulation of a large amount of material in its center (where presumably there is a black hole). All these show that the reports of Leucippus and Democritus to the cosmological role of the vortex are in accordance with the modern research for the creation of the Universe.

c) During the swirl of matter and the creation of the spheroid system due to the existence of heavy bodies, a large portion of the original mixture undergoes a counterforce. The thin bodies escaping to the outer parts of the vortex create a hymen (Aetius, De Placitis, II, 7.2). In the cosmological system of the Atomic philosophers there are two opposing forces. The first one is the centripetal force which is applied to heavy bodies in the center of the mixture and the second one is the centrifuge force, which removes the bodies from the vortex; thus the hymen becomes more and more thinner (Diogenes Laertius, Vitae, IX, 32, 1.4). Subsequently, the mixture constituting from the light atoms are initially wet and muddy, while gradually becomes dry creating the stars. According to the Greek physicist Dimitrios Makrigiannis, it is very possible that a breakdown occurred in various parts of the hymen. These parts formed accumulated volumes of mater, which gradually evolve into stars (Makrigiannis, 1999). The percentage of mater that may be received by the hymen is not infinite; there is a saturation point and beyond it the hymen cannot take other elements (Hippolytus, Refutatio, I, 13.4). These theories indicate that the universe for the Atomic philosophers is a system that follows the laws of mechanics, because it balances between a powerful vortex that creates the central/main condensation and a repulsion that expels the thin bodies towards the hymen so as the stars can be created.

Conclusion

By analyzing the theories of Atomic philosophers it is obvious that their concepts about the basic building blocks of matter which formed the universe and their theories of the evolution of the world are closely related to current scientific discoveries. This necessitates interdisciplinary study of Greek philosophical tradition, in order to be answered questions about the nature of the Universe, which modern cosmology deal with.

References

- Abro A., (1951). *The Rise of the New Physics*, vol. 2. New York: Dover Publications. pp. 447; 490-491; 604.
- Aetius, (1879). *De Placitis Reliquiae*, ed. H. Diels in *Doxographi Graeci*. Berlin: Reimer.
- Aristotle (1924). *Aristotle's Metaphysics*, 2 vols. Editor: W. D. Ross. Oxford: Clarendon Press.
- Galen, (1878). *De Elementis ex Hippocrate Libri II* ed. G. Helmreich. Erlangen: Deichert.
- Diogenes Laërtius (1964). *Vitae Philosophorum*, 2 vols.: Oxford: Clarendon Press.
- Heisenberg, W., (1949). *The Physical Principles of the Quantum Theory* (translated into English by C. Eckart and F. C. Hoyt). New York: Dover Publications. p. 10.
- Hey, T., & Walters P. (2005). *The new Quantum Universe* (translated in Greek by A. Mamalis). Athens: Katoptro Publications.
- Hippolytus (1986): *Refutatio omnium haeresium*. ed. M. Marcovich. Berlin: De Gruyter.
- Hodgson P.E., Gadioli E. & Gadioli Erba E., (1997). *Introductory Nuclear Physics*. Oxford: Clarendon Press. p.7.
- Makrigiannis, D., (1999). *Democritus Cosmology and Ethics*. Athens: Georgiades Publications, (in Greek). pp. 15; 72.
- Novaes, S. F., (2000), *Standard Model: An Introduction*. [Online] Available: <http://arxiv.org/abs/hep-ph/0001283> (January 27, 2000).
- Simplicius, (1895). *Simplicii in Aristotelis Physicorum Libro octo Commentaria*, ed. H. Diels, 2 vols. CAG 9-10. Berlin: Reimer.
- Simplicius (1894): *Simplicii in Aristotelis De Caelo Commentaria*, ed. J.L. Heiberg, CAG 7. Berlin: Reimer.
- Stewart, I. (1998). *Does God play dice?* (translated in Greek by K. Samaras). Athens: Travlos Publications, p. 131.
- Theodossiou, E. and Danezis E., (1999). *The Universe I loved*, Introduction in *Astrophysics*. Athens: Diavlos Publications, vol 2. p. 71 (in Greek).
- Veikos, Th., (1985). *The Presocratics*. Athens: Schoolbooks Publishing Institute, p. 216 (in Greek).