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THE CONTRIBUTION OF BYZANTINE PRIESTS IN ASTRONOMY AND COSMOLOGY
II. GREAT CHURCH SCHOLARS IN THE EARLY BYZANTINE EMPIRE

Vassilios Manimanis [1], Efstratios Theodosiou[1] and Milan S. Dimitrijevic[2*]

[1] *National and Kapodistrian University of Athens, School of Physics, Department of Astrophysics, Astronomy and Mechanics, Panepistimiopolis, Zografos 15784, Athens, Greece*
[2] *Astronomical Observatory, Volgina 7, 11160 Belgrade, Serbia*

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Abstract

In the present paper is analyzed the work of Saint Gregory of Nyssa, Epiphanius of Salamis, Asterius of Amaseia, Cyril I of Alexandria, Synesius, Caesarius of Nazianzus, Nemesius (the bishop of Emesa in Syria). Also, the monk Dionysius Exiguus, who introduced the BC/AD chronology, with emphasis in their contribution to the sciences, especially Astronomy. In particular, we present the cosmological views of Gregory of Nyssa and we comment upon them, as he is considered a great cosmologist and natural philosopher.

Keywords: Byzantium, Natural sciences, Cosmology, Gregory of Nyssa

1. Fourth century: the age of the great Church scholars

The 4th century AD, the first century of the Byzantine (Eastern Roman) Empire, is a period of prosperity for the Graeco-Christian theological philosophy, when the Christian doctrines were consolidated and efforts were made to interpret the cosmology of the *Old Testament*. Upon these topics, the work of the three Cappadocian Fathers: Saint Basil the Great (Basil of Caesarea, 330-379), Saint Gregory of Nazianzus (328-389) and Saint John Chrysostom (347-407), was examined in an earlier paper [1].

Besides the three Cappadocian bishops, the studies of many other leaders of the Church who left their mark not only in Theology but also in Science, mainly with their interesting cosmological and astronomical views are of interest.

* Corresponding author, e-mail: mdimitrijevic@aob.bg.ac.rs, Phone: +381-11-3089-072, Fax: +381-11-2419-553

These latter important figures that appeared at the age of the three great Cappadocian bishops or shortly after them, are the topic of the present paper. In rough chronological order they are: Saint Gregory of Nyssa, Epiphanius of Salamis (in Cyprus), Asterius of Amaseia, Cyril I of Alexandria, Synesius of Cyrene, Caesarius, Nemesius, the bishop of Emesa (Homs) in Syria and finally the monk (abbot) Dionysius Exiguus, who compiled Paschal (Easter) canons and introduced the BC/AD chronology.

During the first centuries of the appearance and propagation of Christianity the official stance of the leaders of the Christian Church was, as we have already mentioned in a previous paper [1], rather negative towards Science because they considered it as a product of the ancient pagan world. Nevertheless, the knowledge of Astronomy was necessary, since a calendar of the new religion's festivals should be devised, especially for the calendrical calculation of the Easter. For this reason the wisest bishops were educated in the 'gentile' culture with its trivium, i.e. Grammar, Rhetoric and Dialectics, and its quadrivium, i.e. Geometry, Arithmetic, Music and above all Astronomy; through Astronomy they studied the cosmology and cosmogony of the *Old Testament*. Actually, in order to reconcile the astronomical views of their age with the cosmogony described in the Book of *Genesis* they wrote treatises *On the Six-day Creation* (*Peri Hexahemerou* or *On Hexameron*) that were staple texts of the spiritual production of the 4th century [2]. As T. Nikolaidis writes, *"The most important texts were the "Homilies to the Six-day Creation" by St. Basil the Great and those by his brother, St. Gregory of Nyssa, treatises that exerted an especially strong influence, not only in the East but also in the West"* [3].

Indeed, Saint Gregory of Nyssa was an expert on the theories of the ancient Greek philosophers on cosmology, life and the Universe, and therefore through his work became one of the most capable judges of their beliefs.

2. Saint Gregory of Nyssa (335-394)

Gregory of Nyssa was the younger brother of Basil the Great (Basil of Caesarea) and he is considered one of the most important theologian of the Eastern Church. Gregory was born in Neocaesarea, on the Black Sea's southern shore, around 335 AD and he must have been educated mainly in Caesarea of Cappadocia having as a teacher his own brother Basil between the years 348 and 357, since he mentions only him as his teacher ([4], vol. 44, p. 125B; vol. 46, p. 1049A). Gregory initially worked as an orator and married Theosebeia; however, after her death he abandoned rhetoric following the advice of Gregory of Nazianzus and he followed the *'emphilosophos vios'* ('life that incorporates philosophy') of the monks and pursued theology studies [5].

He is known to us today as Gregory of Nyssa because he was ordained (by Basil himself) bishop of Nyssa in Cappadocia, a city strategically located on the road leading from Caesarea to Ankara, in order to relieve the latter from the tight grip of the influence of the followers of Arius, a cult leader. In the beginning Gregory had some problems with his diocese, however after the death of the

emperor Valens Flavius Augustus (364-378), a follower of Arius and supporter of his cult, he fully assumed his duties there and his actions from that point onwards is described in his work *To the life of the holy Macrina* [4, vol. 46, p. 960; 6]. Macrina was his sister. After the Council of Antioch in 378 Gregory visited Macrina and their younger brother Petros (Peter) in the place of their exercise on the southern shore of the Black Sea; his conversation with Macrina about the immortality of the soul is contained in his work *On the soul and the resurrection* [4, vol. 46, p. 12], also known for this reason as *The Macrineia*.

Gregory may be inferior to his brother as far as the bishop's actions and practical spirit are concerned; he may also be short of Gregory of Nazianzus in theological thought. However he clearly surpasses both of them in purely philosophical thought, as he was an expert on and researcher of the views of the Greek philosophers about life and the Universe. He also became a tremendous theoretical theologian, who used the teachings of Platonic and Stoic philosophy for the interpretation of the Christian faith [7].

Essentially the Fathers of the Church during that period were attempting to offer answers to core theological issues based on the pre-Socratic positive thought [8].

The work of Gregory of Nyssa, in which the perfect knowledge of Greek culture is evident, is multi-faceted: he wrote explanatory, dogmatic and practical treatises, speeches and letters. He also knew Mathematics and the Astronomy of his age, and he was a great cosmologist.

As a cosmologist, Gregory is known to support the view that the beginning of the Universe is *"seeding power spent [by God] towards the creation of everything"* [4, vol. 44, p. 77D]. This 'seeding power' can be identified in modern cosmological terms as the reason for the formation of the super-dense mass of the Big Bang theory. Also, the phrase *"towards the creation of everything"* shows the dynamic nature of the explosion and the movement from the potential to the naturally existing [9].

His view on Astronomy is that through it *"the intellect is excited towards virtue and the truth is understood through the numbers"* [4, vol. 46, p. 181]. Indeed, according to the late professor of Byzantine studies and academician F. Koukoules: *"The Byzantines knew of two kinds of mathematics: the scientific ones, whose teaching was allowed since, as Gregory of Nyssa writes …* [the above passage is cited - 4, vol. 46, p. 181] *….and the occult ones, which were strictly forbidden. Astronomy, for example, as long as it examined the motions, the sizes and the distances between the celestial bodies, it was being taught; but when it turned into astrology by suggesting that the fate of humans depended on the stars, then it was considered despicable and its teaching was persecuted"* [10].

It can be said from the above that, while Gregory holds faith as the supreme criterion for the truth, he nevertheless does not despise the sciences and Astronomy in particular. The sciences, he informs us, are a jewel that the faithful Christian has to offer to the Church of Christ: "For we are ordered by the Leader of virtue to take ethical and natural philosophy, as well as Geometry and

Astronomy and the science of logic and all studies that those who are outside of the Church are engaged in, to take them from those who are rich in them and accept them in order to use them, because there are cases in which they are useful, when the divine temple of the sacrament must be embellished with the logical wealth. This can be observed to occur even now. The secular education is offered by many as a gift to the Church of God, by people like Basil the Great, who did the right thing during the years of his youth by preparing himself with a wealth of wisdom, comparable to that which Moses acquired living among the Egyptians, and with this wealth of the true wisdom he decorated the house of the Church." [4, vol. 44, p. 360]

Gregory of Nyssa wrote an *Apologetic [speech] on the Six-day Creation* [4, vol. 44, p. 61], in which he tackles cosmological topics found in Basil's *Nine Homilies to the Six-Day Creation* (*Peri Hexahemerou* or *On Hexameron*) [11]. The *Apologetic on the Six-day Creation* supplements both his work *On the construction of the human being* [4, vol. 44, p. 125] and Basil's *Nine Homilies…* In the *Apologetic on the Six-day Creation* Gregory attempts to harmonize the *Old Testament* with the scientific data of his period. However, in this work the influence by the theological positions of the Jewish philosopher Philo of Alexandria (25 BC - 40 AD) are obvious; Philo was the first who tried to combine Plato's philosophy and Biblical theology through his philosophical worldview.

Gregory of Nyssa, in addition to his other significant theological treatises, wrote a large number of *Epistulae* (*Letters*): Out of the 30 *Epistulae* that were saved and are attributed to him, the 28 are genuine, the 29th was written by the sophist Stagirius and the 30th was written by his younger brother, Petros (Peter), the bishop of Sevasteia, and is addressed to *"Gregory of Nyssa, his brother"*. In his *Epistulae* Gregory tackles, in addition to theological issues, astronomical and meteorological topics, such as the size and the number of the stars, the size of the Sun and the size of the celestial sphere. He also offers explanations about the solar and lunar eclipses, lightning, the thunders, the rain, the frost and other phenomena.

With his teaching Gregory continues the theology of Eirenaeus, Origenes, Saint Athanassios and other Fathers of the 4th century. In his *Homilies* are expressed his struggle against the heretical followers of Arius, the Pneumatomachi (or Macedonians followers of Macedonius) and the Apollinarists. In one of his *Letters* he writes that *"among the [members] of the Holy Trinity we find no difference at all."* This statement alone puts him on the opposite side of these heresies and especially the theories of Arius, who demoted the Son (Logos) to a mediator between God and the material Creation [12].

In cosmological issues Gregory of Nyssa generally did not follow the views of his brother Basil and this is the main reason he wrote the *Apologetic on the Six-day Creation* [4, vol. 44, p. 61-124]: to complement and explain certain passages in the corresponding work of Basil that had been misinterpreted. Through this work and from his views we understand that Gregory follows the worldview of Origenes and the Alexandrine School; this School, because of its

Greek and Hellenistic background, interprets the book of *Genesis* in an allegorical, symbolic way, in order to adapt it to the more advanced cosmological system of the Alexandrine natural philosophers: a spherical Earth and Universe, and a geocentric system of movements with the Earth at the centre of the Universe [13]. The *Apologetic on the Six-day Creation* was offered as a present to his brother Petros, later bishop of Sevasteia.

It is important to examine these views of Gregory, which are clearly influenced by the Physics and Cosmology of the pre-Socratic Greek natural philosophers, and how these views are sometimes juxtaposed to the views of Basil without being contrary to them; Gregory praises the work of his brother and regards it as very important.

In any way, as far as the Church Fathers are concerned, their texts reflect personalities highly educated and with a Greek culture; their cosmology is scholarly and scientific, utterly different from the simplistic cosmology of Cosmas Indicopleustes (6th century), which will be analyzed in a future paper.

The basic objections of Gregory of Nyssa are summarized in the following three points:

i) How is it possible that the Earth and the sky have been created from the beginning while at the same time the Earth appears formless and empty?
ii) How is it possible that the Sun appears to be created on the fourth day of the Creation while the light had already been created from the first day?
iii) How is it possible that there were other 'waters' above the firmament?

The answers to these questions are given in the following five points:

1. To the verse of *Genesis*: *"Now the Earth was formless and empty"*, which offered arguments to the Gnostics [14] (who were interpreting it as hinting that the Earth pre-existed before the Creation in a state of formless matter) Gregory gave a different interpretation from the one of his brother. Basil suggested that 'formless' means that the Earth had not yet 'form' its kingdom of plants, while 'empty' (in the Septuagint translation 'invisible') means that the Earth could not be seen either because it was covered by the cosmic waters or because of the original darkness [1]. On the contrary, Gregory suggested that the Earth was 'invisible' because the qualities of the elements that assign to matter its colour and various properties discernible with our vision had not been yet separated. Additionally, he was supporting the view that 'formless' means that matter was in a primeval state and had not yet acquire its proper density. Gregory, influenced by the natural philosophy of the Greek pre-Socratic philosophers, offers his own view: matter, when created, had initially a unified form and subsequently from this primeval matter were separated all these elements that composed the natural world as the latter was understood in that period.

   In the same passage of the *Apologetic*, the 'cosmologist' Gregory of Nyssa also answers another question: "*How the material world can be originated from the immaterial God*?" According to Professor of Theology Elias Moutsoulas: "Gregory stresses that matter was generated by the 'coming together' of 'qualities' such as the heavy, the light, the dense, the rarefied,

the humid, the dry, the bitter, the warm, the colour, the shape, which by themselves are notions and abstract meanings. Since the phrase 'in the beginning' means 'all at once', the verse 'in the beginning God created the heavens and the Earth' also includes the 'creation of all elementary ingredients of the beings that are known to us through our senses.'" [15]

By interpreting these first verses of *Genesis*, Gregory notes that right from the start the 'reasons and causes' for all beings were assigned to the Creation. Based on the cosmological views of his period, he attempts to describe how the world was produced gradually from the 'formless and empty Earth'. He stresses the contrast between Heaven and Earth, which is equivalent (according to the worldview of that age) to the distinction between motion and stillness and contributes to the generation and conservation of living beings. He especially stresses the connection and interrelation of all beings between them and with the 'really being' (the God), from whom they get the potential to exist [15, p. 377].

2. The light and darkness in the verse 1.3 of *Genesis*: *"And God said, Let there be light"* (*Genesis* 1.3) were discussed a lot within the frame of Christian cosmology, since from then on up to this day light is usually identified as representing God and good, while darkness often symbolizes demons and evil. The contrast light-darkness, which essentially is the duality good-evil through the views of Heraclitus and the Pythagoreans, was also an object of study for the Gnostic heretical groups. For example, the followers of Manes, the Manichaists, were attributing to darkness the power of the evil; they believed that darkness was an entity by itself and pre-existed the Creation in order to combat the benevolent nature of God [16].

   Basil the Great could not accept these views and regarded darkness not as a separate entity, but as a passive state of the environment or of the atmosphere, since there is darkness only when light is present somewhere else! The darkness, according to Basil, was created when God created the celestial dome, because in doing this he separated the existing terrestrial world from the divine light. The phrase of *Genesis* 1.3 means, according to him, that God instantaneously illuminated the world with the divine light, which exists since then beyond the firmament. Basil believes that beyond the terrestrial world there is a state of things similar to the one that prevailed before the Creation of the world by God: there the divine or 'uncreated' light prevails, which is not perceivable by the imperfect human senses.

   Gregory of Nyssa separates his position here as well, by suggesting that light during the Creation, a period when darkness prevailed, was not absent but it existed 'inside the particles of matter'. This 'hidden' light appeared with the order of God: *"And God said, Let there be light"*; in this way our world was illuminated.

3. Next in *Genesis* comes the passage: *"God saw the light, that it was good: and God divided the light from the darkness. And God called the light Day*

and the darkness he called Night" (*Genesis* 1.4-5). Astronomically thinking, we notice that this took place before the creation of the Sun and the stars in the firmament (*Genesis* 1.16). Therefore, the notion of the 'day' as the illuminated part of the 24-hour period and of the 'night' as the dark part of that period made no sense for the rationalistic ancient Greek astronomy.

Basil the great supports the view that this day and night, before the Sun, was not due to the revolution of the Sun around the Earth but due to light pulses, because of cycles of 'diffusion and contraction' of light, as God had ordered.

Gregory's explanation of this passage is once again different: being deeply influenced by Aristotelian physics, he believes that light presents a natural upward motion. Therefore, when it was ejected by the various elements, it immediately followed a motion towards the heavens ('upward'), where it concentrated. When it reached the spherical borders of the created world, in other words the ninth crystalline sphere, it assumed a circular motion. This way, as it followed its circular orbit on the ninth sphere, it illuminated the Earth from the one side, the 'day side', but as it continued its course the thicker part of the 'unformed Earth' was inserted between the light and our world, forming a shadow, i.e. the darkness of the night. This prevailed towards the opposite direction from the rays of the circularly moving light.

4. *Genesis* informs us that the 'two great lights' were made in the fourth day (1.16), when the Earth had already been created. Basil, who generally does never differentiate between the divine and the 'created' light, supports the view that in the fourth day the *carriers* of light were created, implying that all the celestial bodies are self-illuminated and that their differences in brightness are due only to their different sizes. Gregory of Nyssa on the other hand assumes that the celestial bodies are illuminated from the outside and that the Universe has tremendous size. He also believes that the stars have been formed by aggregations of particles; because these particles were not of the same nature, the stars differ in their properties. For example, the Sun was formed from brighter particles than the Moon, and for this reason it is much brighter than the latter.
5. Another intriguing passage in *Genesis* that created problems for the Greek-educated bishops was the following: "*Let there be a firmament in the midst of the waters, and let it divide the waters from the waters*" (Genesis 1.6). In other words, after the Creator God had made the Earth and the heavens, and after the creation of light and the separation of the day from the night, an 'expanse' or firmament was created in order to separate the celestial from the terrestrial waters. Here the Jewish world view prevails, according to which the Earth is surrounded by the universal waters; this in turn follows the most ancient Mesopotamian theory about the structure of the Universe (see Figure 1) [17]. Here appear together two cosmological elements totally alien to the classical Greek and Hellenistic astronomy: the expanse-firmament and the universal waters. Both Basil and Gregory use in their

explanation the celestial spheres of the Ptolemaic (Hellenistic) astronomy. Basil the Great thinks that the firmament is a solid sphere under the one that defines our world; the firmament keeps the universal waters – which are of the same nature as the terrestrial waters – in its upper side. In this way the firmament is identified with the eighth sphere of the fixed stars in the celestial sphere system of Claudius Ptolemy. Above it, according to Saint Basil the Great, there is the ninth sphere that forms the boundary of the created Universe and most probably is identified as the sphere of the 'primal cause' (the counterpart of the Primum Mobile of medieval and Renaissance astronomy). In the context of the Aristotelian and Ptolemaic view for the Universe, as it later reached the West, this ninth sphere is the 'second crystalline sphere' of the zodiac. In the West, of course, as in the Dante's *Divine Comedy* model, they proceeded further and considered the tenth sphere as the crystalline sphere of the Primum Mobile, placing beyond all these the ethereal heavens (see Figure 2) [18]. According to Basil, the water is extremely valuable; therefore, these 'universal waters' are a kind of celestial reservoir constructed by the providence of God in order to have enough water for his terrestrial creation until the end of the world.

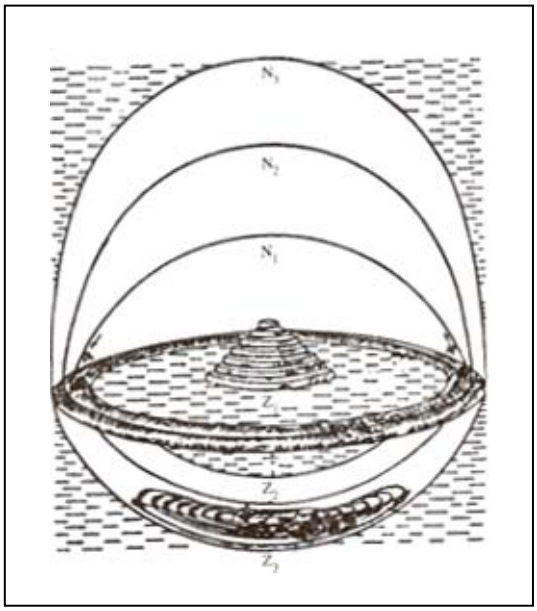

Figure 1. The Universe of the Babylonians. The three domes of the sky (N_1, N_2 and N_3) and the three zones of the Earth (Z_1, Z_2 and Z_3) can be seen. The uppermost terrestrial zone (Z_1) is dominated by the seven-terraced ziggurat, a religious building of the Babylonians.

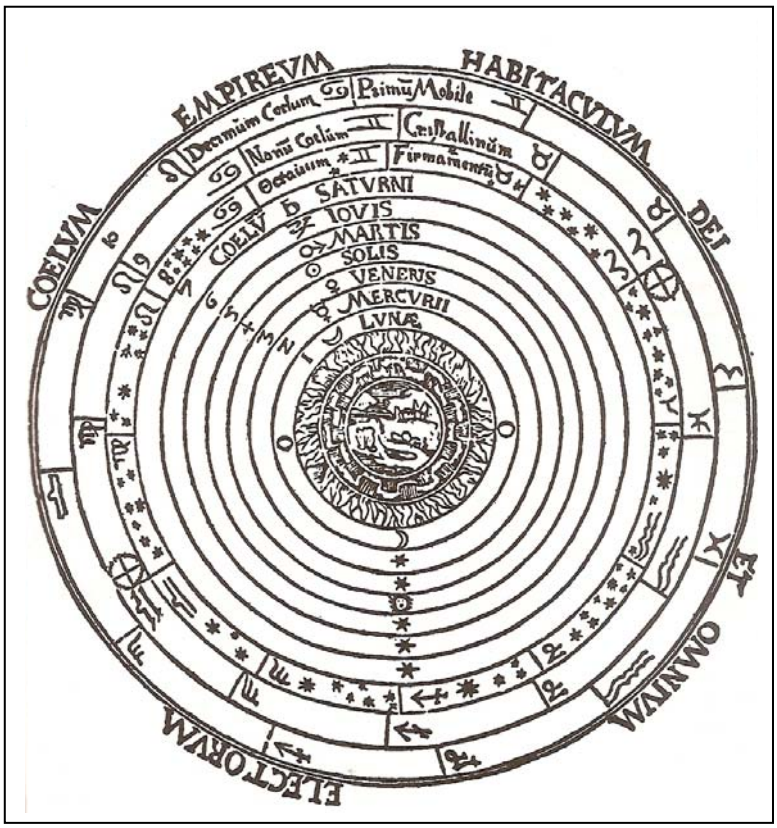

Figure 2: The Universe of Aristotle with the Latin names of the 'coeli' (heavens), as they were known in the West. In its centre are the Earth, the region of the air and the region of the fire. Going outwards we see the spheres of the seven 'planets' (Moon, Mercury, Venus, Sun, Mars, Jupiter and Saturn) and of the three zodiacs. The first sphere of the zodiac corresponded to the 8th 'coelum', that of the fixed stars; the second sphere corresponded to the 9th crystalline heaven and the third one to the 10th heaven of the Primum Mobile. Beyond these there are the ethereal heavens, the abode of the Divinity.

On the contrary, Gregory believes that the firmament is essentially the sphere of the created Universe itself and that it is not made from a solid material because this way the sphere would be too heavy and it would collapse. As for the celestial universal waters, these, according to the scholarly bishop, are 'spiritual': they do not belong to the created world, but to the transcendental world of God.

Gregory of Nyssa, beyond his cosmological explanations concerning our world, writes also about superstitions like the one he mentions about the Byzantine people of his time, that on the New Year's Day they were taking care so that they would first meet or have in their house (as the year's first guest) a person who would bring them good luck during the new year [19].

Of great philosophical value is Gregory's work *Great Catechism* (translated in English as *The Catechetical Oration of Gregory of Nyssa*) which has been translated in the major European languages. A central place in the works of Gregory is occupied by his teaching about man and his salvation. His work *On the Construction of Human* [4, vol. 44, p. 125-256] is an essay of Christian anthropology of the same level as the essay *De Natura Hominis* (*On the nature of man*) by Nemesius of Emesa [20]. In the work *On the Construction of Human* Gregory complements what Basil the Great exposed in his nine *Homilies On the Six-day Creation* (*Peri Hexahemerou* or *On Hexameron*), where he had omitted this topic.

According to theologian and professor of Theology V. Feidas: *"In the whole of his teaching, Theology is in perfect harmony with Anthropology and Cosmology, centred on the triadic God and His incarnation in Jesus Christ"* [21].

The basis of Gregory's philosophical thought is the metaphysical notion of existence. God is the 'one who really exists'. From this existence stems everything and humans also 'participate' in it, with the following essential difference: God has the 'Existence' by Himself, while man, as His creation, possesses the Existence 'through participation'. God creates the world/Universe from what does not exist through his Logos (logical speech or relation). The world was created from nothing with the will of triadic God alone [22]. The human being, the centre of the material world, is for Gregory a creation of God that lies on the boundary, as he writes, between the visible (or material) and the invisible (or spiritual) creation. Indeed, Plotinus, the 3rd century philosopher, placed Nous (mind) and the ideas between God and the soul, while Origenes identified Nous and the ideas with Logos, which in Christian thought took the meaning of the second person of the Holy Trinity. Gregory, however, does not accept the place of Nous as an intermediate and identifies it with the Father. In the position held by the ideas in the system of Plotinus and Origenes Gregory places the angels, who he regards, like the souls, creations of God, although they belong to the invisible or spiritual creation.

Finally, Gregory mentions that human, being the centre and the reason for the world, aims at the transition from 'in our image' to 'in our likenesses. Human's spiritual march, he writes, has no end, because humans are imperfect and God is infinite. Faith and knowledge are strictly separated. Through logical knowledge alone it is impossible to understand the divine being; also, our mind and thoughts act inside the frames of space and time, and they always 'see' things within frameworks or 'separations'. Thus, according to Gregory of Nyssa, we cannot approach the divine essence thought the way of the logical thought: God transcends our understanding (or perception) and the human vision, since He is the ultimate invisible and incomprehensible Being. Human wisdom, Gregory writes (transferring into a theological level the teaching of Socrates and Plato about ignorance) is *"the understanding of the incomprehensibility of the divine being"* [6, p. 686].

Scholar K. Gronau stresses in his work the influence of Poseidonius the Stoic upon both Basil the Great and Gregory of Nyssa; he writes that especially Gregory, in addition to Philo and Origenes, used as a direct stoic source the commentary on Plato's *Timaeus* by Posidonius (a disputed work), in which in an eclectic way are exposed views of the Pythagoreans, the Platonic and the Stoic philosophers [23].

According to Gregory the neoplatonic belief that the world originated from the essence of God and the Manichaean belief that the world was created by another, evil God, are both erroneous. Gregory states that the beings did not originate from the essence of God. The first and basic differentiation is the one between the 'one who really exists', which is uncreated (actiston), and all the created beings, which owe their origin to the former [15, p. 375]. Nevertheless, Gregory writes that he himself does not find great antithesis between Neoplatonism and Christianity; this probably explains why his work exerted a significant influence to both the Byzantine occult intellectuals and the Western Medieval one. Our personal opinion is that his work is worthy of further study and detailed research, in particular its cosmological ideas [12].

The whole work of Gregory of Nyssa has been included by J.-P. Migne in the volumes 44 to 46 of the *Patrologia Graeca* [4], while it was also published by Werner Jaeger [22], and its essay *On the Construction of Human* by J. Laplace [24]. In addition, emeritus professor of Theology at the University of Athens Elias D. Moutsoulas wrote the book *Gregory of Nyssa-Life, Works and Teaching*, where he writes in detail and full references all about the life, the works and the teaching of this great Church Father [15]. Gregory died after the Council of Constantinople (394), in which we know that he participated. The Third Ecumenical Council in 431 called him *"man second only to his brother in both word and manners"*, while the Seventh Ecumenical Council in 787 called him *"Father of Fathers"* [15, p. 53]. The Church sanctified Gregory; his memory is celebrated on January 10 by the Orthodox Church and on March 9 by the Catholic Church.

3. Epiphanius of Salamis or of Cyprus (315-403)

An important Church Father of the 4th century was the scholar Epiphanius, bishop of Constantia (the Salamis of the ancients) in Cyprus and archbishop of the whole island of Cyprus (367-403), hence the appellation *Kyprios* (Cypriot, of Cyprus).

This noted Church writer was a strong opponent of Origenism. He left a rich collection of theological works, including *Ancoratus* (the 'well anchored man', 374 AD), an epitome of the dogmatic teaching of the Church, especially about the Trinity dogma, and *Panarion* (meaning Medicine-chest) or *Adversus Haereses* (*Against the heresies*, 375 AD), where he analyzes and refutes all 80 heresies that had appeared up to his age [25]. In addition, he studied the issue of the celebration of the Easter, which is of historical interest to all astronomers; on this topic he disagreed with the great Cappadocian bishops, insisting on the

proto-Christian tradition of celebrating it on the first Sunday after the Jewish Passover.

Epiphanius was a polymath and could speak several languages: Greek, Hebrew, Syrian (Aramaic), Coptic-Egyptian and (less competently) Latin; for this reason Eusebius Hieronymus calls him *Pentaglossos* ('five-tongued') [26].

This Church scholar, aside from the polemics by which he is known, wrote in Greek two unusual books. The first one, composed in Constantinople for a Persian priest, was entitled *On Measures and Weights*, assumed its final form around 392 and covers a very wide range of subjects, from the geography of the Palestine to the measures and weights that are mentioned in the *Bible* and were used by the Jews [27]. It consists of three sections, the first one dealing with the canonical books and the translations of the *Old Testament*, the second one dealing with the measures and weights (that gave the title to the whole work) and the third one dealing with the geography of the Holy Land. It can therefore be characterized as a biblical encyclopaedia. It has been saved in its Syrian (Aramaic) translation and partly in its original Greek version. The texts appear not to have been given a polish but consist of rough notes and sketches, his modern editor, Allen A. Shaw, concluded; nevertheless Epiphanius' work on metrology was important in the history of measurement [27].

The second peculiar book by Epiphanius bears the title *Of the 12 stones in the decoration of Aaron*. It actually describes the gems and especially the twelve ones that decorated the diadem of the Jewish high priest Aaron.

Therefore, Epiphanius, whose memory is celebrated by the Orthodox Church on May 12, could be classified on behalf of these two works as one of the earlier Byzantine scientists. In addition, he was an ardent persecutor of astrology, which he denounced by the name of 'astronomy'.

In his philosophy, Epiphanius believes that humans have limited abilities for the understanding of the *Bible* and he considers the holy tradition as a necessary supplement to it; thus, the truth exists only in the Church, which accepts both the *Bible* and the holy tradition of Christianity.

The works of Epiphanius, in spite of their many errors, offer a wealth of data that would otherwise be unknown to us.

4. Asterius of Amaseia (4th century)

Asterius, the bishop of Amaseia of Pontos, succeeded as a bishop Eulalius in *circa* 385. He was contemporary of Basil of Caesarea and the other great Cappadocian Fathers. Asterius was distinguished especially for his theological and administrative work, and for his rhetorical ability, as well as for his occupation with the sciences.

From his work, 16 *Homilies* were saved and are included in *Patrologia Graeca* [4, vol. 40, p. 155-480], while Photios I of Constantinople in his renowned *Bibliotheca* or *Myriobiblon* mentions ten of them along with a summary of their content [4, vol. 104, p. 201-224]. These *Homilies* contain a wealth of mathematical and astronomical propositions, which indicate the level

of the respective knowledge in the 4th century AD. One example is offered by the professor of Byzantine studies and academician F. Koukoules: "According to Asterius of Amaseia [4, vol. 40, p. 301], the student could not understand astronomy if the teacher did not 'simulate the motion of the pole by turning knowingly his eyes'" [10, p. 131].

Thus, Asterius could be classified as a priest and religious author with parallel studies in Mathematics (Arithmetic and Geometry) and in Astronomy.

One of his best-known works is his *Homily to the celebration of Calendae* [4, vol. 40], which was delivered on the occasion of the January calendae, January 1 of the year 400 AD.

5. Cyril I of Alexandria (370-444)

Cyril I of Alexandria was born in Alexandria in either 370 or 376 and he received a significant education in his native city, which was the cultural capital of the empire. He was the nephew of the archbishop of Alexandria Theophilus (385-412) and thus he was from an early age associated with the Church of Alexandria. He became a monk and he went to stay in the desert along with Isidorus of Pelousion. He later returned in Alexandria, where he was ordained deacon and priest by his uncle. Finally, in 412, after his uncle's death, he succeeded him in the patriarchal throne. He was archbishop and patriarch for 32 years. He was a dynamic personality and his zeal often reached the borders of exaggeration.

Cyril I was the main opponent of Nestorius, the heretics and the Jews. He closed the temples of the Novateans and confiscated their property; he sealed the synagogues and confiscated their property, too. He clashed with the augustalius (commander) of Egypt Orestes because of these violent acts and because of the tragic death of the eminent mathematician and philosopher Hypatia in 415, since he was accused as the motivator of the angry mob of Catharoi or Paravalaneis.

Cyril I became a prolific author of the Eastern Church and the total of his work was included in *Patrologia Graeca* [4, vol. 68-77]. For example, the work *Against the Galileans* by the emperor Julian the Apostate is known only from its refutation by Cyril I. Cyril wrote mainly *Letters*, which are significant for both their theological content and their astronomical and historical value, since they contain astronomical information about the calculation of the Christian Easter date, probably as a continuation of the astronomical work *Paschal Canons* of Anatolius (late 3rd century).

Twenty nine out of Cyril's 100 *Letters* are on this topic, and they were probably used by the monk Dionysius Exiguus as the source for his own *Paschal Table*, from which he derived the date of the Easter starting from the birth of Jesus Christ. It is known that the responsibility for the calculation of the Easter date and for informing all the Christian churches had been assumed after the First Ecumenical Council (325) by the Church of Alexandria, because of the flourishment of astronomy studies in its schools. Cyril I compiled Paschal tables

starting from the age of Diocletian, which probably extended to the future up to the year 531 [28].

The rest 71 *Letters* by Cyril I are about the Christological question. Cyril I, who also was one of the leading organizers of the Third Ecumenical Council (431), was proclaimed a saint of the Orthodox Church and his memory is celebrated on January 18, along with the memory of Athanasius the Great, as well as on June 9.

6. Synesius (370-414)

Synesius, a famous Greek orator, poet, philosopher, astronomer and author, was born *circa* 370 to a prosperous family of gentiles in Cyrene. His family hired for him private tutors who taught him philosophy and the sciences. Subsequently, he went to Alexandria, where he completed his studies in Philosophy as a student (along with his brother Euoptius) of the famous philosopher, mathematician and astronomer Hypatia, with whom he was connected with a long friendship. It seems that he owed a lot to Hypatia, for he exalts her in certain letters by calling her *"mother and sister, most respected teacher, blissful lady, most divine soul and all that is honourable in both essence and name"* [4, vol. 66, p. 1352].

In Alexandria Synesius became acquainted with the Christian religion but he did not seek to be baptized, although Christians wanted him in the Church because of his education. Synesius could not understand the Christian dogma of the resurrection of the dead, since him, as a philosopher, favoured opposite beliefs, such as the pre-existence of the souls, the eternity of the Universe, etc., and he rejected the resurrection of the dead.

Eventually, because Synesius as a leading figure in Cyrene had saved Ptolemaïs from the looting raids of the barbarian tribes of Libya and he had succeeded (with a four-year mission-intercession to the emperor Arcadius) in decreasing the taxing of its population, the people of Ptolemaïs after the death of the their bishop asked that Synesius be ordained as his successor. Synesius refused, since he did not want to divorce his wife in order to become a bishop, neither to change his philosophical beliefs. When he spoke about these objections to the archbishop Theophilus of Alexandria, he recommended to him to be baptized and become a Christian without dissolving his marriage or renouncing his philosophical views; it would be enough just to avoid teaching these views. Celibacy was not imposed on the clergy back in that period, not even for bishops.

After these compromissorial propositions, Synesius was baptized and then Theophilus ordained him priest and then bishop of Cyrene's Ptolemaïs (410-413/14) without Synesius renouncing his philosophy.

Consequently, Synesius can be viewed as a characteristic figure of the transitional period of the expansion and the final prevalence of Christianity in Egypt and North Africa, a model of philosopher high priest of that age with tolerance towards the gentile culture. He taught as a follower of the ancient

Greek spirit who inserted his moral and ethical values into the Christian framework.

Synesius, as a polymath, composed hymns in the ancient Dorian dialect and wrote many treatises, essays and speeches (*Dio, sive de suo ipsius instituto*, *Aegyptus sive de providentia*, *Encomium calvitii*, *De regno* etc.). In addition, he studied Neoplatonic philosophy, Physics and Astronomy, while at the same time he was especially critical against astrologers. He is regarded as the philosopher who blends in his work Neoplatonic views with Christian positions to a greater extent than Plotinus (3rd century).

His major works are:

- His oration *De regno* (= *On Kingship*), which was addressed in 399 to the emperor Arcadius and it is considered a work that 'inaugurated' the period of the national anti-barbarian movement for the annihilation of the influence of the Goths in the army and the administration of the empire. According to Synesius, the ideal state must be based on rationalism and philosophy.
- The *De insomniis (On Dreams*), addressed to his teacher Hypatia [4, vol. 66, p. 1432], from whom he asked advice regarding the construction of an astrolabe, an astronomical instrument that was used for the observation of the stars and the determination of their altitude above the horizon. His scientific interests are attested by this letter, in which occurs the earliest known reference to a hydrometer, and by a work on alchemy in the form of a commentary on pseudo-Democritus.

From his many works, the one entitled *Over the donated astrolabe* [4, vol. 66, p. 1577-1588] is addressed to his friend Paeonius in Constantinople, to whom he sends as a gift this astrolabe that he had constructed himself.

The loss of this speech is significant, as it included the full description of the instrument, which was made of silver and included a model of the celestial dome with one thousand stars; from this information it can be deduced that it should be quite large in size. The late professor of Geodesy and Astronomy at the National Technical University of Athens, I. Argyrakos, published in 1958 a relative *Study of the 'Astrolabe' of Synesius of Cyrene* [29]. According to that study, Synesius was most probably the first Greek astronomer we know of that he wrote a work about an astrolabe.

Finally, Synesius wrote more than 159 *Letters* on various subjects, which illuminate the history of his period. These *Letters* were admired in the Byzantine Empire for their excellent writing style – the *Suda* encyclopaedic dictionary describes them as 'admired letters'. These *Letters* were printed in Vienna in 1792 by Gregorios Konstantas from Pelion (as he is mentioned in this edition) along with a commentary by the Greek monk and ecclesiastical writer Neophytos Kafsokalybites (†1780).

Synesius, condemned astrology in these words: "So the savants foresee the future, some of them by observing the stars, others by observing torches and shooting stars, others by 'reading' the intestines, by hearing the noises, the sitting or the flying of the birds. For them the so-called symbols of future events

are obvious 'writings' and voices and comparisons done for other purposes that are considered as important for everything." [4, vol. 66, p. 1284]

In addition to all these, Synesius can be regarded as one of the most important ancient chemists, since according to R. Herschel [30] he invented a 'hydrometer' or 'areometer', which he called 'varyllion', as he wrote to his teacher Hypatia (*Epistulae* 15).

Synesius as the bishop of Cyrene waged from 410 a struggle against the oppressive commander of Cyrene Andronicus and then against the Africans who attacked the region with continuous raids. In this final struggle he fell on the battlefield as leader of the defence around 411, when Cyrene was lost forever for the Hellenistic civilization.

7. Caesarius of Nazianzus (4th century)

The Church author Caesarius (†369) was the younger brother of Gregory of Nazianzus (329-390) and his memory is celebrated by the Orthodox Church on March 9.

Caesarius studied Philosophy and Medicine in Alexandria. It is included in this study because a great geographical work is attributed to him. This work covers the Balkan Peninsula, Asia Minor, Syria and Palestine. Apart from the wealth of geographical information, this treatise, which is similar to a modern travel guide, contains several pieces of meteorological and astronomical knowledge and information.

In addition Caesarius gained a great fame as a medical doctor. Thus, when he moved to Constantinople, he became the chief-doctor of the emperor Constantius II (Flavius Julius Constantius) and then of his successor Julian the Apostate after a recommendation of the latter's friend and renowned doctor Oreivasius. Because he accepted this position and became the official doctor of an enemy of the Christians, Caesarius was reproved by his brother Gregory [12, p. 263]. Afterwards, emperor Vales appointed Caesarius as the 'overseer of treasures and paymaster of the public money' in Nicaea of Bithynia, where he died around 369.

Caesarius of Nazianzus is with a low probability the author of the significant theological work *Four Dialogues* [4, vol. 38, p. 852-1189].

8. Nemesius of Emesa (4th to 5th century)

The philosopher Nemesius, the bishop of Emesa (nowadays Homs of Syria) was contemporary to the great eastern Fathers of Church. Very few elements are known about his life. He flourished *circa* 400 AD, while he is better known to the historians of science from his famous work *De Natura Hominis* (*On the Nature of Human*), which is attributed by certain researchers to Gregory of Nyssa, due basically to its similarity with the latter's *On the Construction of Human*.

In this work Nemesius connects the Greek philosophers (Plato, Aristotle, Epicurus, the Stoics etc.), the physician Galenus and others with his contemporary Christian scholarly tradition in an effort to build an anthropological system in accordance with the Christian philosophy that was taking shape in his period. The philosophy of Nemesius is basically a Christian Neoplatonism with an Alexandrian overtone.

The whole text of *De Natura Hominis* is included in the *Patrologia Graeca* [4, vol. 40, p. 503-818] and could be described as the epitome of Christian anthropology: in this work the spiritual and material nature of human, the *"microcosm of the whole universal creation"* according to Nemesius, is described.

Author N.K. Laos in his book *Cognitive Science, Philosophy and Orthodox Theology*, writes: "Nemesius in this work studied the human being as a soul-and-body unity and wrote about the dialectic relation between body and mind. More specifically, this great Church Father writes that the soul is not body, it is not a material entity, but it is rather an essence 'independent and bodiless', 'an entity without size or volume or parts', that at the same time it is united with the body without any confusion." [31]

Geometry, Astronomy, time, Anthropology and Theology are inseparably connected in this work of Nemesius which is composed by 44 chapters. It deals with the generation and the essence of the soul, with its union with the body, with the power of the soul, with the freedom of the human being and with the divine providence in relation with the fate. It refutes the beliefs of the Manichaeists, the Eunomians (also known as the Anomœans) and the Apollinarists, who had adopted the fatalistic beliefs of the Greek philosophers. For all these the work of Nemesius occupies a high place in the Christian philosophy; it was esteemed by the subsequent bishops and it was used first by John of Damascus (7^{th} to 8^{th} century) in his *Exact Exposition of the Orthodox Faith* [4, vol. 94, p. 789-1228] and afterwards (9^{th} century) by the monk Melitius in his work *On the Construction Of Humans*.

Such a major work, as it was natural, was extensively translated: in Armenian (8^{th} century), in Latin (11^{th} and 12^{th} cent.) and afterwards many times in the West (Antwerp 1575, Oxford 1671, Halle 1800-1802, etc.). This work is valuable for its references in the history of time measurement (see e.g. G.J. Whitrow: *Time in History. Views of time from Prehistory to the present day* [32]), while it was used by the authors of this paper in a book [33] about the views of the Stoics on the re-creation of the Universe.

9. Dionysius Exiguus (5^{th} to 6^{th} century)

The abbot, Church author and chronologist-astronomer Dionysius Exiguus or Dionysius the Minor is more widely known to astronomers and chronologists as the introducer of the Christian chronology from the birth (incarnation) of Jesus. Very little is known about his life, mainly from what his contemporary monk Flavius Magnus Aurelius Cassiodorus (480-583) wrote in his work *De*

divinis Lectionibus (c. xxiii). A knowledgeable person who knew well Greek and Latin, Dionysius translated, *inter alia*, in Latin the letters and the *Paschal Table* of the bishop Cyril I of Alexandria, the treatise by Gregory of Nyssa *On the Construction of Human*, the life of Saint Pachomios and the Codex of Ecclesiastical Canons from the time of the Apostles to the Third Ankara Council (375).

The late Greek astronomer K. Khassapis [34] writes that Dionysius was a Greek monk from what is now the shores of Romania, the Scythia Minor of that period, hence he is called a Scythian. He made the voyage to Rome in 497 as a member of a mission from Constantinople and he stayed there becoming abbot of a monastery until 540. He became famous as both an ideal translator of the Greek Fathers of the Church and an author of his own works; he kept writing until his death in 546. His most important work is known as *Collectio Dionysiana* and contains two collections of religious canonical texts: the first collection consists of Greek texts with Latin translations and the second consists of Papal decisions. This work exerted a considerable influence in the West. The whole work of Dionysius, mainly his translations, is included in Migne's *Patrologia Latina* [35, vol. 67, p. 9-527].

Close to the beginning of the 6th century, Dionysius Exiguus started an attempt to determine with precision the date for the celebration of the Christian Easter. After he was prompted by Pope John I (523-526) and ordered by the emperor Justinian I (527-565), he tried to recalculate this date starting with the year of the birth of Jesus Christ. He based his calculations on the *Paschal Table* of the bishop Cyril I, which was numbering the years starting with the year of the emperor Diocletian.

Dionysius compiled new calendrical tables for the exact determination of the Easter Sunday. He was so absorbed by this huge task and the complicated calculations involved, that some minor mistakes slipped into these.

With the astronomical elements and the mathematical tools of that age he finally concluded that the year he finished his calculations was the year 248 of the Diocletian era our 532. It seems that the year he began constructing his Paschal Tables was 525. The fact that he ended in 532 may be related to the fact he knew that the Julian cycle of Easter 532 years long. Then Dionysius decided to count the years from the incarnation of Jesus Christ and thus our current numbering was introduced (Aera Christiani or Christian era). He calculated the Easter date for 95 years, from 532 to 626 by translating the *Paschal Table* of Cyril I (*De Ratione paschae*, *Argumenta pascalia*). His calculations for the year of Christ's birth are included in his work *Cyclus Decem Novennalis* and they were based on the texts of Clemens of Alexandria (150-229), who wrote that Jesus was born in the 28th year of the reign of Octavian Augustus. He then supposed that Jesus was born on December 25 of the year 754 from the building of Rome (754 A.U.C.) and not in the correct 749 A.U.C (= Ab Urbe Condita). He made the correspondence 754 AUC = 1 AD (primo anno Domini), not taking into consideration the introduction of a year '0' – he could not even think of it, since there was no zero in his age! [28, vol. II, p. 264]. Had he added such a year

in his chronology, Dionysius would have relieved us from the confusion regarding the celebration of the century change.

10. Conclusions

The contribution of the scholarly bishops of the early Byzantine period to the natural sciences is in our opinion a very important topic to study and research, as it is rather neglected. The cosmological views of Gregory of Nyssa are markedly influenced by the Physics and Cosmology of the pre-Socratic Greek natural philosophers, as he writes about them in his several writings. Of special interest are these views when they are juxtaposed with the views of Basil of Caesarea in his *Nine Homilies to the Six-Day Creation* (*Peri Hexahemerou*). In both views of the world, which were echoed in the subsequent works by Church Fathers, the celestial bodies are considered spherical, like the sky and the firmament. The motion of the celestial bodies is generally circular, although in no place in their texts is the constant speed circular motion mentioned, as it is described in Ptolemy's *Syntaxis (Almagest)*, a basic element of the Greek and Hellenistic astronomy. From this point of view the Christian cosmology tends to lift an obstacle for the refutation of the astronomical system, which was not so much the difference between heliocentric and geocentric system, but rather between circles and ellipses [13].

In any case, by studying the texts of the early Byzantine Church Fathers/scholarly bishops we easily realize that they were men of deep Greek culture and education. They study in detail the universal issues with a view based on the Greek and Hellenistic texts and it is at once scholarly and scientific, entirely different from the simplistic world views that appeared in the following centuries, such as the one of the monk Cosmas Indicopleustes (6^{th} century) with his *Christian Topography* [4, vol. 88, p. 445], which we shall examine in a future paper.

It should also be stressed that the works of the great Church scholars of the 4^{th} and 5^{th} centuries influenced to a large degree both their contemporary and the subsequent Western scholarly bishops. For example, Saint Augustine, bishop of Hippo (354-403) is influenced by Gregory of Nyssa in his view that in the human soul we discover traces of the properties of the Trinitarian God, as well as in his definition of time, which Gregory considers as 'dilation of the soul', division and tearing of the soul 'towards hope and memory' [33, p. 24].

According to author K.D. Georgoulis most modern theologians and philosophers exalt Gregory's contribution to the anthropological problem in relation with the incarnation and to the ontological 'transcendism' and existential starting point. Indeed, the fundamental metaphysical position of Gregory of Nyssa is not the essence, the 'what is this?', but rather the existence, the 'is', in other words the realization of the existence [7, p. 686].

It should be noted once more that, by reading the works by Gregory of Nyssa, the authors realized that it certainly needs further analysis and detailed research, especially its cosmology.

This paper is the continuation of our previous work on the connections between spirituality and science [36, 37] and on the contribution of the Church in Byzantium to the natural sciences [1, 38]. In our next paper in this series we shall examine the simplistic cosmology of Cosmas Indicopleustes (6th century) and his geographical aspects and writings.

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