The work of Claudius Ptolemy, as the epitome of the Macedonian Legacy in History, and of the Hellenistic and Alexandrian Science and Civilization

PANAGIOTIS PAPASPIROU, Ph.D. Candidate, Section of Astrophysics,
Astronomy and Mechanics, Faculty of Physics,
National and Capodistrian University of Athens. Hellas
Email: p.papaspirou@academy.edu.gr

XENOPHON MOUSSAS, Professor in Space Physics,
Director of the Astronomical Observatory of the University of Athens,
Director of Astrophysics Laboratory, Section of Astrophysics,
Astronomy and Mechanics, Faculty of Physics,
National and Kapodistrian University of Athens. Hellas
Email: xmoussas@phys.uoa,gr

Abstract
We propose to investigate the Hellenic, as well as the Hellenistic and Alexandrian Legacy, a direct product of the Macedonian legacy, and through the study of the life and work of the Alexandrian Giant of Astronomy Claudius Ptolemy. Claudius Ptolemy, as a historical Figure, as a Polymath, as an Astronomer, and as a Symbol, represents the World-Picture and the Civilization Alexander the Great offered to the Global Cultural Heritage. Macedonia, already Hellenic from its pre-historic times, conquers the Hellenic World, inherits all the great peaks of the Hellenic Culture and spreads through the world, generating the Hellenic Oecumene, and encompassing all the other Great Civilizations it meets. Within this sociocultural setting Alexandria in Egypt, the Capital city, the Cosmopolitan Metropolis, is founded. Alexandria becomes a central node of the cultural semantic web and an economic center, unifying East and West through the trading routes and the cultural osmosis, for many generations that followed, in the Hellenic and Roman civilization. Claudius Ptolemy is a full representative of this Civilization, an "Epitome" of the Hellenistic civilization, and the Hellenic Worldview, while his works reflects the cultural achievements of this civilization within the realm of Astronomy and other branches of Knowledge.

1. Introduction

Alexander the Great, within his quests in the Eastern Mediterranean, becomes the founder of the city of Alexandria, on the place of the small port of Rhacotis, as a natural and geographically well protected base for his operations, a city intended to supersede Naucratis, and also as a direct geographical connection for accessing the rich Nile valley.

Thus, Alexandria acquires already the merits of a central node serving for military and commercial reasons, as well as a bridge between Europe, Africa and Asia. The first rulers of the Ptolemaic dynasty, Ptolemy I the Soter, and Ptolemy II the Philadelphus, accomplish to realize Alexander's vision, and are the first to transforming the Capital city of the Ptolemaic Kingdom into a center for Culture, that is a center for teaching and further developing the Fine Arts, the Natural Sciences, the Applied Sciences, through the establishment of the Musaeum of Alexandria, which includes the famous Library of Alexandria (Durant, 1954). The Musaeum, which can be considered as a "noospheric Pharos" embracing all the great Civilizations of that era, that is the civilizations included within the geographical territory of Alexander's quests, is a center functioning similar to a University, and to a Technological and Scientific Research Center, while the Library of Alexandria serves as the most vast and detailed data base of the Ancient world, providing to the Scholars and Polymaths, which are engaged in the Teaching, the spreading of Knowledge, as well as for research of a quality of first degree, with all the valuable necessary knowledge. Within this cultural and social setting Claudius Ptolemy, many generations after the first king of the Ptolemaic Dynasty, lives and creates his own unique work (El-Abbadi, 1992).

Alexandria has already become a military, a political, a commercial, and a cultural center of the Ancient World, just as Alexander, the most prominent Personality of the Macedonian in particular, and the Hellenistic, in general, civilization and culture, has envisioned. Furthermore, the general setting of the function and the structure of that, which could call as the "Alexandrian Paradigm", especially the intellectual atmosphere dominating within the Musaeum and the Library, shall also become a Symbol, a need for achievement for the forthcoming great Civilizations that followed, the Byzantine, the Arabic and Islamic, and the European civilization (Laiou, 1992; Meri, 2004). Many kings and rulers always try to mimic and copy the "Alexandrian Paradigm", through the establishment of analogous Institutions and Universities, analogous to the ones already existing and flourishing within the Metropolis of Alexandria, many centuries after its acme.

More specifically, the capital city of Alexandria, at Srabos' time, includes and offers at a global scale, as conceived and existed by following the spirit of these times, all the characteristics of the Hellenic Polis, that is the Hellenic City – State, including the Great Theater, the Emporium (Exhange), the Apostases (Magazines), the Gymnasium and the Palaestra, together with the Musaeum, and its most famous Library of Alexandria, and the Royal Palaces, the Temples of Poseidon and the Serapeum. All these architectural monumental constructs reflect within space and time all the aspects of the Hellenic civilization (Hansen, 2006), which serve as symbols and metaphors within the spiritual world of the Hellenic tradition.

Also, a very short list of the names of prominent figures who lived for a part of their lives, and studied in Alexandria, covers the whole impression we receive by studying this Metropolis of the Ancient World, and gives us many insights into the framework of Ptolemy's own works and achievements. We can mention among the great personalities giants such as Archimedes, Aristarchus of Samos, Callimachus, Erasistratus, Eratosthenes, Euclid, Herophilus, Hipparchus, Pappus and Hero. Each one of these historical personalities

can also be regarded as Symbolic Figures within the realm of the sciences of Astronomy (Dreyer, 1953; Pannekoek, 1989), Mechanics, Pneumatics, Hydraulics, Automata Mechanisms, Computing devices and machines (Moussas, 2012; Moussas, 2010; Freeth et. al. 2006), Mathematics, including the Euclidean Geometry, the Plane and Spherical Trigonometry, the introduction of the Stereographic projection, Number Theory, Geography, Medicine, Music Theory, and all branches of Literature, including the study of Logic and Grammar (Marlowe, 1971). Many novel scientific disciplines are being introduced, while other already existing disciplines are further investigated and expanded, not only in the Metropolis of Alexandria, but also in other great economic and cultural centers, such as Syracuse, Rhodes and Pergamum.

2. The works of Claudius Ptolemy

Ptolemy belongs to a wide scientific and astronomical tradition, whose roots are traced back to the Orphic tradition of the Hellenic civilization, that is the first attempt for the transition from the realm of Mythos to the realm of Logos. Ptolemy can be regarded as a personality, that is as a Scientist and Astronomer, investigating and writing in the space of discourse we described, that is on the common ground built by Astronomy, Astrology, Music, and Optics, but we may also consider him as a symbol, as a symbolic figure of the Patriarch of Astronomy, Astrology, Music and Geography, as a man who stands beyond time, or even better, above time (Toomer, 1970), and who transcends all the traditions of the Great civilizations that followed, that is the Byzantine, the Arabic and Islamic, and the European civilization.

This Hellenic tradition continues to the Ionian Renaissance, with the appearance of the Philosophy of the Presocratic philosophers, as well as with the development of Mathematics and the laying of the foundations of the various branches of Science (Lloyd, 1970), that is the Natural sciences, the Social sciences and Humanities, the Applied sciences, and the technological Know-how, serving both the “divine curiosity” of the Philosophers and Polymaths, as well as economic and military purposes.

This tradition, in its astronomical aspect, further continues with the introduction of the astronomical theories of Eudoxus of Cnidus and of Callipus of Cyzikus, develops further within the space of discourse of the Platonic and Aristotelian school, by a combined effort of mathematicians, astronomers and physical scientists, passes through the landmarks of the Giants of Astronomy , that is of Apollonius of Perga and Hipparchus of Nicea, meets the advances of Eratosthenes, and culminates with the introduction of Ptolemy’s work (Dreyer, 1953; Pannekoek, 1989; Jones, 2010).

Here, we are just listing a very broad and somehow vague historical outline about the metamorphoses of the content of the science of Astronomy, a science regarded as most fundamental and important according to the Worldview of the Hellenic culture and civilization, in general, and also accompanied by many other realms of Knowledge.

In the present, we shall outline only the efforts given for the exposition of Ptolemy’s

approach to Cosmology and Astronomy, that is the geocentric and geostatic Universe according to the Aristotelian philosophical doctrines (Jones, 2010; Pedersen, 2011). In order to complete this short historical outline, we also have to mention the doctrine of Heliocentrism as well, the concept of a Heliocentric solar system, or Universe, which starts already within the broad context of the Pythagorean school, especially within the teachings of Philolaus, continues with the heliocentric theory of Aristarchus of Samos (Theodossiou et. al. 2002; Heath, 1913), and his disciple Seleucus of Seleucia, but seems to disappear in the forthcoming generations, after the publishing and spreading of Ptolemy's major astronomical world. The reasons about this historical and epistemological phenomenon are somehow obscure, while this subject deserves a better and more thorough investigation, than the one presented in this article.

We may proceed with the titles of Ptolemy's work, since this could be an indication about the spirit of his age, as well as about the certain mentality introduced, by him and within the framework of the culture he lives within. These are the philosophical claims and the metaphysical and physical doctrines of a whole tradition (Burtt, 1954), and all its accompanying societal and intellectual factors which enabled the growth and the expansion of an open community of astronomers and polymaths, already from the very begin of the development of the science of Astronomy, and especially within the Alexandrian Zeitgeist, as implemented within the city of Alexandria.

These works (Toomer, 1970; Evans, 1998) include the "Mathematical Compilation", also known as "The Greatest Compilation", or the "Almagest", a work appearing in thirteen books, his treatise called as "The Planetary Hypotheses", his book entitled as "The Analemma", his work entitled as "The Planisphaerium", a work about Spherical Trigonometry and the stereographic projection, as well as its other major work entitled as "The Geography", or as "Cosmographia" or "Geographike Hyphegesis", in eight books, his treatise about "Optics", in five books, his "Tetrabiblos Syntaxis", a treatise about Astrology, in four books, his other work "Karpos" or "Centiloquium", and his work called "Harmonics", with its subject being about Music Theory.

Thus, we observe that Ptolemy feels to be compelled to investigate at the same time the realm of Astronomy, introducing in a novel way a most important astronomical Paradigm, known also as the Ptolemaic Paradigm, and by the parallel exposition of the astronomical observational instrumentation, the realm of Astrology, which appears in a systematized, mathematized and scientific manner, according to the understandings and the scientific consensus of Ptolemy's era, as well as of the forthcoming generations after him, the realm of Optics, and of Music Theory, and finally the science of Geography.

Ptolemy encompasses these branches of knowledge as a united whole (Cornford, 1966; Clayton and Davies, 2006; Mourelatos, 1986), and studies each of them in a systematized and mathematized manner, always staying in accordance with the most strict scientific criteria, his methodology and exposition of each of the subjects he studies meet all the modern scientific criteria, that is the criteria of the modernization of Science in general, which can be regarded as the era of Newton, Leibniz, and their successors. In Ptolemy's

work, the heavenly or celestial realm, that is the realm of the celestial bodies and fixed stars, their influences upon the earthly realm, and the human fate in particular, the musical expression and manifestation of these Harmonies, incorporated within celestial realm of the Music of the Spheres, and the musical influence on the human Fate and Ethos, but also the study of the Light and the related physical phenomena, all of them are studied thoroughly, in detail, and according to the highest scientific standards of his age.

More important, all these subjects of Knowledge, as "memetic themes", appear again and again within the thought and the work of the astronomers and polymaths that followed (Walker, 1996), as we observe them evolving within the thought and the work of the Giants of Astronomy that followed, including the tradition and the school of all the Great Arabic and Islamic astronomers (Saliba, 1994), as well as Copernicus (Rosen, 1995) and Kepler (Kepler, 1997).

We may suspect that the whole body of Ptolemy's work can be interpreted as the organic view imposed on the Aristotelian Universe, that is as a philosophical metaphor which describes the heavenly and the earthly phenomena in terms of a hierarchical structure of the Universe, where all of its levels interact among each other, and describing all the contents and the functions of the physical phenomena in terms of an organic unity (Cornford, 1966; Clayton and Davies, 2006; Mourelatos, 1986).

This certain aspect continued to survive in the generations of scholars and polymaths which succeeded Ptolemy's era, and his major works, spreading through the historical net of the generations of the next following great Civilizations decided in a critical manner the inherent growth and the developmental tendencies of Astronomy, Astrology, Optics, Harmonics and Geography.

We observe the generation of a complex network built by the unification and close interaction of the spaces of discourse of Astronomy, Astrology, Optics, Harmonics, and Ethics, and we believe that the whole compendium of these aspects of Knowledge, was born under the Hellenic cultural influence, interconnected under this particular spirit, and took its final form within the realm of the Hellenistic and Alexandrian era, while the epitome of this achievement was created and published in the Cosmopolis of Alexandria, by one of the greatest astronomers, the Giant Claudius Ptolemy.

This whole "noospheric holon" continued its solitonic existence, and spreading, as an Autopoietic structure, in the forthcoming civilizations, always based on all the great works of Ptolemy, the offspring of the major contributions of the Hellenistic and Alexandrian culture.

Thus, Ptolemy is the epitome of all acquired and accumulated knowledge of its time, while a fundamental characteristic of his work refers to the fact that he ordered, systematized, and introduced a regular, orderly, and harmonious compilation of all of the aspects of Reality, incorporating the totality of the physical phenomena in a most simple and clear manner. Ptolemy also introduces novel concepts and techniques, such as the notion of the equant

point for describing the planetary orbits (Pedersen, 2011; Jones, 2010), or his Ptolemaic intense diatonic scale (Partch, 1979) which unifies the celestial music, that is the Harmony of the Spheres with the human perception about symmetry and harmony, on the mesoscopic scale of the Universe.

In Ptolemy's own words, in his introduction to the Almagest, his presentation is twofold: to offer a concise recapitulation of all the gained astronomical knowledge up to his time, aimed at the skilled professional, but also to discuss at length, to the best of his ability, all the newly introduced ingredients of his astronomical Paradigm.

Ptolemy follows this exact reasoning, as well as this guideline of thought in all his other major works. We may understand that his major astronomical work, the "Almagest", presupposes the Aristotelian corpus of Physics, and the detailed knowledge of the Hipparchean and Archimedean tradition, by the skilled reader of this astronomical compendium, thus his exposition is mainly mathematical, and for didactic reasons. Ptolemy is not only an ingenious Mathematician, he is also a skilled Physical Philosopher, although he does not feel obliged to present in full the physical astronomical theory he presupposes as valid.

Ptolemy starts his exposition in the Almagest (Pedersen, 2011; Jones, 2010) by stating intuitive and plausible first principles, arguing in favor of the Aristotelian concept of Cosmos, by the means of certain physical arguments. He also introduces in the structure of his astronomical Paradigm his three eponymous aws of composition of the planetary orbits, a scheme which can be regarded as similar to Feynman's introduction of his three principles of describing the phenomena within the framework of the theory of Quantum Electrodynamics, that is the three basic actions for the Feynman diagram elements (Feynman, 1998).

We cannot yet be certain of which of these achievements trace back to Hipparchus of Rhodes, since Ptolemy exposes in his astronomical treatise the law of the eccentric point, that is the eccentric description of a planetary orbit, the law of the deferent and epicycle, and the law of the equant point. The first two laws already exist within the teachings of Hipparchus of Rhodes, but we cannot be certain about the introduction of the equant point within the framework of the Hellenistic astronomy. The issue of the introduction of the equant point can be regarded as a major mathematical and physical achievement of Ptolemy, since he "saves the astronomical phenomena" in a most fruitful manner, but on the other hand, he also contributes to the generation of a polemic of the successive generations of Astronomers and Polymaths that followed his era, since the equant point seems to be unsatisfactory from an epistemological and philosophical view, contradicting with a certain interpretation of Aristotle's doctrines about the perfect circular motion of the celestial bodies (Kuhn, 1957). This polemic also enabled the inner evolution and the metamorphose of the Ptolemaic paradigm through the ages, that is its gradual perfection, according both on epistemic as well as on observational grounds.

In particular, Ptolemy proceeds in the investigation of the heavenly phenomena by posing

the Aristotelian cosmological paradigm (Elders, 1966) as the foundation of his own astronomical paradigm, presented in the form of plausible and self-verified empirical statements, which anyone may accept as self-evident. The heavens are attributed with a spherical form, the Universe is geocentric and geostatic, the Moon the Sun, the then known planets, and the fixed stars gyrate around Earth, the center of the Universe.

Then, he proceeds with the introduction of the mathematical machinery used in his paradigm, referring to Spherical Trigonometry, and to the calculation of his exhaustive and extensive table of chords, as well as with the observations of the obliquity of the ecliptic, that is the apparent position of the Sun as projected on the sphere of the fixed stars. Then, the rising and setting of the celestial objects, the length of the day and of the night, the determination of latitude, the shadows of the gnomons at the equinoxes and the solstices, are also investigated. The length of the year, the motion of the Sun, the motion of the Moon, the lunar parallax, the motion of the lunar apogee, the sizes and the distances of the Sun and the Moon relative to Earth, the solar and lunar eclipses, all of them are also investigated in detail. Via the introduction of the eccentric point, the system of the deferent cycle and epicycle, and the notion of the equant point, associated astronomical models of the planetary orbits are constructed, that is Ptolemy studies the motion of the Sun, the Moon, of Mercury, Venus, Mars, Jupiter and Saturn, their stations and the characteristics of their retrograde motion, in general, as well as their motion in latitude, and their conjuctions, oppositions and culminations, both in the case of the inferior, as well as for the superior planets. Ptolemy also offers a star catalogue, and classifies the then visible and known stars according to the Hipparchian model of classification of the magnitude of the stars (Pedersen, 2011; Jones, 2010).

We can regard Ptolemy as the Patriarch in the realm of Astronomy, a personality who creates within the physical Universe a human Universe, that is his own view on the orderly, mathematically structured, and causally explained Universe, the Cosmos, a Cosmos full of all connections and relations among Nature, Man, and the Celestial, or Divine, realm, always searching for Simplicity, Harmony, Symmetry and Causal explanation on the basis of Physical laws.

3. Two major landmarks of the Hellenic Culture

Ptolemy's work is exceptional, according to many aspects, including the epistemological aspect, the ontological aspect, the methodological aspect, as well as the place of his work within the History of Science and of the Great Civilizations. The Ptolemaic astronomical Paradigm has survived for many centuries, and dominated in the conceptual spaces of successive great Civilizations, that is the Hellenistic and Alexandrian, the Byzantine, the Arabic and Islamic, and the European civilization (Laiou, 1992; Meri, 2004; Dreyer, 1953).

The same also holds for his influence upon the realm of Astrology, with its "Tetrabiblos" (Ashmand, 1822; Evans, 1998) being the most referred and cited work within the community of astrologers, and also polymaths, from the Alexandrian period up to the period of Johannes Kepler and perhaps Sir Isaac Newton.

The long historical route of Ptolemy's "Almagest" enabled the continuous flow of its inner metamorphoses as a Paradigm, that is a succession of improved or somehow altered Paradigms, which evolved through the ages, and the shaping of the mentality and the World-picture of successive generations of astronomers' and polymaths' communities. The same also holds for his 'Tetrabiblos" and his "Optics", while his "Harmonics", via the introduction of the Ptolemaic intense diatonic scale, resulted to a major impact on the Theory and the practice of Music, during the period of the transition from the great Renaissance of the 14th century to the era of Baroque, for example upon the influence of the great Theorist of Music, and also important composer, Gioseffo Zarlino (Reese, 1954).

The Giant of Astronomy Johannes Kepler feels obligated to "tune" the Harmony of the Spheres he is seeking in the planetary motions using a musical scale very similar to Zarlino's musical doctrines (Kepler, 1997), which are both of musical as well as of metaphysical character. These great personalities come in discourse with the meaning and the structure of Ptolemy's work, they are influenced by his Worldview, and whenever they modify or alter it, in reality they follow his footsteps in order to improve the way of thinking of a Great Master, or even overcome him, a fact which they do indeed succeed, as they are able to perform within the standards and their novel sociocultural environment, which absolutely differs than the Ptolemaic one. Thus, Ptolemy serves as one of the exemplars of the Hellenistic tradition in Science, while his own line of thought encompasses the whole of the Hellenic civilization.

This long historical route and endeavor within the "noospheric space" of the Hellenic civilization starts already from the era of the Orphic texts, with the introduction of Logos within the natural Order, via the concept of the Cosmic Laws that govern Nature and Man at the same time, continues to the epoch of the Ionian Renaissance, that is with the appearance of the Presocratic Philosophers (Schroedinger, 1996) and their various and rich in number and fundamental ideas Philosophic Schools, reaches the era of Plato (Vlastos, 1975) and Aristotle (Llyod, 1968), up to the era of Ptolemy, that is the Hellenistic and Alexandrian era.

Ptolemy's work, whether astronomical, physical, mathematical, philosophical, musical or astrological, is a culmination of many "layers of discourse", and the meeting point of many "spaces of discourse". These are amalgamated in a systematic and holistic manner, while Ptolemy, following the line of thought of the long Tradition he belongs, at the same time acts as the epitome of a certain World-spirit, the Hellenic one, and of a certain World-picture, the Hellenistic and Alexandrian, whose roots and foundation are traced back to the Macedonian Legacy (Austin, 2006; Boardman G. et. al. 2001).

We may regard that Ptolemy's work is only "the top of the iceberg" of a whole cultural and historical process. We can trace the origins of these "spaces of discourse" within the Glossogony and the Cosmogony of the Hellenic conception about Cosmos, its abstract and rich conception about the Universe, which embraces the world of the human existence and the world of the divine, following the long routes of the application and imposition of Logos on Nature (Schroedinger, 1996). Within the Ionian Renaissance, and the appearance

of the first Presocratic philosophers, the Hellenic culture experiences beyond the introduction of Philosophy, the introduction of Mathematics, as an axiomatized approach built upon Theorem Proving, and Physics, as a discipline based upon theoretical considerations and empirical evidence.

Other branches of Science, such as the science of Medicine, already transform from a set of practices and rituals into a scientific body of Knowledge, as we understand them even in our times. We also observe the appearance and further development of the science of Logic, of Rhetorics and of Dialectics, but also major breakthroughs in the field of the Arts, and most importantly the appearance of the Theater, and of the systemization and axiomatics, always correlated with metaphysical speculations, in the field of Music.

By considering them within their totality, all these "noospheric leaps" originate and emerge through the political and social appearance of a novel form of government, the Polis, that is the City-State. The Hellenic Polis includes the Agora, the common place of all citizens for their commercial activities and their everyday communication, the Vouli (Parliament), the Theater, while in many cases these City-States experience the novel introduction of the political system of Democracy, both in its theoretical definition and justification, as well as in its concrete historical implementation (Hansen, 2006).

We can furthermore trace these great achievements into the fractal nature of the Hellenic Geosphere, the Hellenic Biosphere, and the Hellenic Noosphere, as induced within the framework of the City-state, a theoretical conception introduced already from important researchers of this new field of investigation (Dimotakis, 1999; Dimotakis, 2005).

We observe at all levels a profound diversity and plasticity within these conceptual schemata, as well as a continuous succession of recurring stages of Chaos and Order within the flow of the historical time, from the first begin of the cultural Glossogony and Cosmogony, that is for the introduction of novel systems of Language, informal and formal ones, in order to perceive the natural, but also the social phenomena, under a new light. The fractality encountered in the geosphere and the biosphere of the Eastern Mediterranean region, the geographic region which is regarded as the fountain of the Hellenic Civilization, from its very begin, is responsible for the richness and the degree of complexity, and diversity, that is the fractality encountered in the noosphere of the Hellenic civilization (Dimotakis, 1999; Dimotakis, 2005; Dimotakis, 2010). The continuous process of the successive alternation of periods of Order which are followed by periods of Chaos, also contributes greatly to the successes and the landmarks of this Civilization, since it constitutes a main characteristic of the development of the Hellenic civilization and culture. Here, we may observe that the two important landmarks, as well as turnings of the Hellenic civilization, the Ionian Renaissance and the Hellenistic period, could be considered as two historical eras exhibiting a high degree of Order and of Emergence, both at the collective social level, as well as at the level of the appearance of great Personalities.

We may regard that the birth of the Hellenic civilization, with all its peculiar features, its fractality and its plasticity, which marks its idiosyncratic character, serves as the fountain of

various "Metaparadigms", that is of "Paradigms of Paradigms", and of Autopoietic structures, as well as structures exhibiting solitonic behavior within the flow of the historical time, which appear and reappear again, in their various historical phylogenetic forms, and during the course of the historical time, in all the great Civilizations that followed. Each of these civilizations, the Byzantine, the Arabic and Islamic, and the European civilization, inhere these forms in the form of "cultural memes", and alter or modify them in order to serve the historical and social needs of each epoch, contributing with creative ways along the routes already established, during the course of their greatest acme.

Ptolemy introduces through his collected work the most immense and lifelong surviving "cultural" and "scientific memetic structures" (Heylighen and Chielens, 2009) into the astronomical communities, and the communities of the polymaths of the great Civilizations that followed.

Thus, we may investigate Ptolemy as an important node within the complex network of the Hellenic heritage to Astronomy and Science (Spandagos, 1995; Spandagos, 2011), as well as for the generations that followed, and express his position within the flow of historical time as the offspring of at least two great outbreaks of the sociocultural evolution of the Hellenic civilization. The first such outburst of creativity and of the wide expansion of the mental and cultural horizons refers to the long tradition of the Presocratic philosophers, while the second refers to the Macedonian legacy within the historical content of the evolution of our Global Heritage, that is to the conquests of Alexander the Great in general, and the osmosis between the Hellenic civilization with the great civilizations of Egypt and of the Persian empire, just to mention two important components of this process, and the foundation of the capital city of Alexandria, with its Pharos, but also its "noospheric Pharos", that its its Musaeum and its Library.

Ptolemy introduces an astronomical Glossogony for the totality of the then observed natural and social phenomena, whose trends are being followed on his footsteps up to the era of Johannes Kepler (Koestler, 1960).

The generation and the publication, as well as the circulation of Ptolemy's work, among the communities of the polymaths or the lay public, brings into the foreground issues referring to the emergent Complexity for the scientific Paradigms, and of the synergetic behavior of the production in Science within the historical content of each civilization. Acting as a symbol, or as a nearly mythical astronomical Figure, Ptolemy can be regarded as the epitome of the Hellenic tradition he acquired, as a scientist and astronomer within the Hellenistic and Alexabdrian period of science, and of cultural development, in general.

4. Acknowledgements

The authors want to thank Professor Pavlos Dimotakis and Dr. Konstantinos Karamanos for many useful remarks, suggestions, directions and ideas, given for the study and the investigation of the scientific, and astronomical, work of Claudius Ptolemy, and the

exposition of its sociocultural roots, tracing back to the origins of the Hellenic civilization and the Hellenistic and Alexandrian era, in particular.

5. References

Ashmand, J. M., (ed.) (1822), *Ptolemy's Tetrabiblos*, London: Davis and Dickson. Reprinted, Bel Air, MD: Astrology Classics, 2002.
Austin M. M. (2006), *The Hellenistic World from Alexander to the Roman Conquest*, second edition, Cambridge.
Boardman J., Griffin J., Murray O. (2001), *The Oxford History of Greece and the Hellenistic World*, Oxford.
Burtt, E., A. (1954), *The Metaphysical Foundations of Modern Physical Science*, New York: Kegan Paul.
Clayton, P., and Davies, P., (Ed's) (2006), *The Re-Emergence of Emergence: The Emergentist Hypothesis from Science to Religion*. Oxford: Oxford University Press.
Cornford. F. M. (1966), *Plato's Cosmology: The Timaeus of Plato*, The Liberal Arts Press.
Dimotakis, P. (2005), *Χάος και Τάξη: Η Μοίρα των Ελλήνων* [*Chaos and Order: The Destiny of the Greeks*], in Greek, Georgiadi Publications, Athens.
Dimotakis, P. (1999), *Η Αρμονία της Δημοκρατίας και το Χάος των Ελλήνων* [*The Harmony of Democracy and the Chaos of the Greeks*], in Greek, Georgiadi Publications, Athens.
Dimotakis, P. (2010), *Το Χάος στον 21ο Αιώνα* [*Chaos in the 21st Century*], in Greek, Athens.
Dreyer, J. L. E. (1953), *History of Astronomy from Thales to Kepler*, 2nd edition, Dover Publications.
Durant, W. (1954), *Our Oriental Heritage*, Simon & Schuster.
El-Abbadi, M. (1992), *Life and Fate of the Ancient Library of Alexandria*, Paris: Unesco, 2nd edition.
Elders, L. (1966), *Aristotle's Cosmology: A Commentary on the De Caelo*, Assen, Netherlands: Van Gorcum.
Evans, J. (1998), *The History and Practice of Ancient Astronomy*, Oxford University Press.
Feynman, R. P. (1998), *Quantum Electrodynamics* (New ed.). Westview Press.
Freeth, T.; Bitsakis, Y.; Moussas, X.; Seiradakis, J. H.; Tselikas, A.; Mangou, H.; Zafeiropoulou, M.; Hadland, R.; Bate, D.; Ramsey, A.; Allen, M.; Crawley, A.; Hockley, P.; Malzbender, T.; Gelb, D.; Ambrisco, W.; Edmunds, M. G., (2006), "Decoding the ancient Greek astronomical calculator known as the Antikythera Mechanism", *Nature,* v. 444, pp. 587-591.
Hansen, M. G. (2006), *Polis: An Introduction to the Greek City-State*, Oxford University Press
Heath, T.L. (1913), *Aristarchus of Samos, the ancient Copernicus: a history of Greek astronomy to Aristarchus*, Oxford, Clarendon.
Heyighen, F., and Chielens, K. (2009), "Evolution of Culture, Memetics" in Meyers, B., "Encyclopedia of Complexity and Systems Science", *Encyclopedia of Complexity and Systems Science*, Springer.
Jones, A. (ed.) 2010, *Ptolemy in Perspective: Use and Criticism of his Work from Antiquity to the Nineteenth Century*, New York: Series: Archimedes, Vol. 23.
Kepler, J. (1997), *Harmonice mundi libri V, The Harmony of the World*, (Trans. Aiton, E. J., Duncan A.M., Field J. V.)

Koestler, A. (1960), *The Watershed: a Biography of Johannes Kepler*, Garden City: Doubleday.
Kuhn, T. (1957), *The Copernican Revolution: Planetary Astronomy in the Development of Western Thought*, Cambridge Mass: Harvard University Press.
Laiou, A., E. (1992), *Byzantium: A World Civilization*, Washington, DC, : Dumbarton Oaks
Llyod, G. E. R. (1968), *Aristotle: The Growth and Structure of his Thought*, Cambridge.
Lloyd, G. E. R. (1970), *Early Greek Science: Thales to Aristotle*, New York:Norton
Marlowe, J. (1971), *The Golden Age of Alexandria*, Trinity Press.
Meri, J., W. (2004), *Medieval Islamic Civilization*, New York: Routledge.
Mourelatos, A. (1986), "Quality, Structure, and Emergence in Later Pre-Socratic Philosophy." *Proceedings of the Boston Colloquium in Ancient Philosophy*. 2, pp. 127-194.
Moussas, X., (2012), *Ο Μηχανισμός των Αντικυθήρων: Πίναξ, Το Πρώτο Μηχανικό Σύμπαν* [*The Antikythera Mechanism: Pinax, The First Mechanical Universe*], in Greek, EEF, (Ένωση Ελλήνων Φυσικών).
Moussas, X. (2010), "The Antikythera Mechanism: A Mechanical Cosmos and an Eternal Prototype for Modelling and Paradigm Study" , *Adapting Historical Knowledge Production to the Classroom***,** *Section A,* 113-128*.*
Pannekoek, A. (1989), *A History of Astronomy*, Dover Publications.
Partch, H. (1979), *Genesis Of A Music: An Account Of A Creative Work, Its Roots, And Its Fulfillments*, Second Edition, Da Capo Press.
Pedersen, O., (auth.), Jones, A., (ed.) (2011), *A Survey of the Almagest*, Springer New York.
Rosen, E. (1995), *Copernicus and his Successors*, London: Hambledon Press.
Reese, G. (1954), *Music in the Renaissance*, New York.
Saliba, G., (1994), *A History of Arabic Astronomy: Planetary Theories During the Golden Age of Islam*, New York University Press.
Schroedinger, E., (1996), *Nature and the Greeks* and *Science and Humanism*, (For. By Roger Penrose), Cambridge.
Spandagos, E., Spandagou, R. (1995), *Οι Αστρονόμοι της Αρχαίας Ελλάδος* [*The Astronomers of Ancient Greece*], in Greek, Αίθρα, 1995.
Spandagos E., (2011), Αρχιμήδους Βίος και Έργον, [*Life and Work of Archimedes*], in Greek, Αίθρα, 2011.
Stephenson, B. (1987), *Kepler's Physical Astronomy*, Studies in the History of Mathematics and Physical Sciences, 13. New York: Springer.
Theodossiou, E., Danezis, E., Manimanis V., , Kalyva E.-M. (2002), "From Pythagoreans to Kepler: the dispute between the geocentric and the heliocentric systems", *Journal of Astronomical History and Heritage,* Vol. 5, No. 1, pp. 89 – 98, 2002.
Toomer, G. J. (1970), "Ptolemy" in *The Dictionary of Scientific Biography*, New York
Vlastos, G. (1975), *Plato's Universe*, Seattle: University of Washington Press.
Walker, C. (ed.) (1996), *Astronomy before the telescope*. British Museum Press .