ΠΡΑΚΤΙΚΑ | PROCEEDINGS

3ο Διεθνές Συνέδριο Αρχαίας Ελληνικής και Βυζαντινής Τεχνολογίας

19-21 Νοεμβρίου 2024

ΜΕΓΑΡΟΝ ΜΟΥΣΙΚΗΣ ΑΘΗΝΩΝ

3rd International Conference Ancient Greek and Byzantine Technology

19-21 November 2024

MEGARON THE ATHENS CONCERT HALL

ΟΡΓΑΝΩΣΗ

ΕΤΑΙΡΕΙΑΣ ΔΙΕΡΕΥΝΗΣΗΣ ΤΗΣ ΑΡΧΑΙΟΕΛΛΗΝΙΚΗΣ ΚΑΙ ΒΥΖΑΝΤΙΝΗΣ ΤΕΧΝΟΛΟΓΙΑΣ

NOESIS
ΚΕΝΤΡΟ ΔΙΑΔΟΣΗΣ ΕΠΙΣΤΗΜΩΝ & ΜΟΥΣΕΙΟ ΤΕΧΝΟΛΟΓΙΑΣ

Το Διοικητικό Συμβούλιο της Εταιρείας Διερεύνησης της Αρχαιοελληνικής και Βυζαντινής Τεχνολογίας (ΕΔΑΒυΤ) ανέλαβε την ανάρτηση στην ιστοσελίδα της (www.edabyt.gr), σε ψηφιακή μορφή, των εργασιών του 3ου Διεθνούς Συνεδρίου Αρχαιοελληνικής και Βυζαντινής Τεχνολογίας (Αθήνα 19-21 Νοεμβρίου 2024).

Οι εργασίες είχαν γίνει αντικείμενο κρίσεων και σχολιασμού από την Επιστημονική Επιτροπή. Επι πλέον, έγιναν κι άλλες παρατηρήσεις και σχόλια κατά την συζήτηση που ακολούθησε μετά την προφορική τους παρουσίαση στο Συνέδριο.

Οι εργασίες αναρτώνται όπως κατατέθηκαν από τους συγγραφείς μετά την ολοκλήρωση του Συνεδρίου. Οι συγγραφείς φέρουν την ευθύνη του περιεχομένου της εργασίας τους, τόσο ως προς τις απόψεις τους όσο και ως προς την ακρίβεια και την ορθότητα των στοιχείων που παραθέτουν.

The Board of Directors of the Association for Research on Ancient Greek and Byzantine Technology (EDAByT) undertook the posting on its website (www.edabyt.gr) of the papers presented at the 3rd International Conference on Ancient Greek and Byzantine Technology (Athens, November 19-21, 2024).

The papers had been subject to reviews and comments by the Scientific Committee. Additionally, further observations and comments were made during the discussion that followed their oral presentation at the Conference.

The papers are posted as submitted by the authors after the conclusion of the Conference. The authors are responsible for the content of their work, both in terms of their views and the accuracy and correctness of the data they present.

HELLENISTIC SCIENCE: FROM OBSERVATIONS TO PURE SCIENCE AND TECHNOLOGY BASED ON THE LAWS OF PHYSICS. THE EXAMPLE OF THE ANTIKYTHERA MECHANISM

Xenophon Dion. Moussas [1]
1 Department of Astrophysics, Astronomy and Mechanics, Faculty of Physics, School of Science, National and Kapodistrian University of Athens
+306978792891, e-mail: xmoussas@phys.uoa.gr , xdmoussas@gmail.com

Abstract. Science and technology were used in military applications and in cartography during the campaigns of Alexander the Great, who was trained accordingly. Science and technology based on the laws of physics developed tremendously during the Hellenistic period.

The birth of determinism with Philosophy in Greece is of prime importance for the birth of Civilization and the evolution of Humanity. Determinism and causality created philosophy, the sciences and today's technical civilization. The article presents the evolution of science, mainly during the Hellenistic period.

Determinism and Causality lead inescapably to the notion and necessity of the laws of physics expressed in appropriate mathematics. The basis of science is systematic experiments with precise measurements. The beginnings of scientific methods in ancient Greece can already be found in the prehistoric period. The solid foundations are laid with the tradition of the Ionian philosophers. They flourished and spread throughout the world during the Hellenistic period among the Hellenic World founded by Alexander the Great and continued by his successors. The leading role of geometry is presented with theorems and proofs. Today's civilization is the evolution and continuation of the Hellenistic Civilization, Science and Technology in particular.

The birth and evolution of natural philosophy are discussed, the study of nature with the laws of physics with the birth of Astrophysics and the possible contribution of observations and comets and meteorites to the birth of naturalism and astrophysics.

The use of the laws of physics in technology is presented through the prime example of the Antikythera Mechanism, the use of determinism and the laws of physics, as understood and mathematically expressed at the time, in predicting natural phenomena, especially astronomical ones. The programming of this ancient computer is its software written with the gears with which its programmer predicts all the astronomical phenomena that were known at the time. The use of determinism in practice becomes apparent, from the conception of the

construction of a machine that many would consider a disgrace, to the construction of the mechanism at the optimal possible scale.

Keywords: science, causality, determinism, astrophysics, laws of physics in technology, Antikythera mechanism

1 The birth of the science

The Greek Miracle, i.e. the birth of philosophy and the sciences, is based on theoretical scientific thinking and especially on theoretical mathematics with proofs of arithmetic, geometry, algebra, physics and technology are gifted.

Science and technology began in primitive form in prehistoric times, probably even palaeolithic times. The concept of determinism is born gradually and is soon accompanied by the perception of the existence of laws of physics which can only be correctly expressed by appropriate mathematics, just as the Pythagorean perception imposes. With the beginning of the agricultural revolution, astronomical knowledge about the movements of the Sun and the Moon, and the changes of the seasons, became necessary, as Plato says, for weather forecasting and travel.

Mankind's observations of phenomena gradually led to a better formulation of the laws of physics, which led to the birth of pure science and technology based on the laws of nature. Astronomy in prehistoric times demanded and created more precise mathematics, geometry, arithmetic, trigonometry, and algebra. Astronomy, with its complex calculations, also required the creation of computers, such as the Antikythera Mechanism.

The introduction of the concept of calendars based on the Sun and the Moon. At the same time, mathematics enters, arithmetic to measure the days of the month and year and geometry to determine directions, such as the position of the sunrise on the horizon, and the height of the Sun. The greatest advance in the sciences is the introduction of theoretical proofs and theorems.[1] Heron also informs us that [Practical] Geometry originated in Egypt but was made theoretical by proofs from Thales and this is the greatest progress in science.[2] According to our tradition, it is Pythagoras who, to use a phrase of Galileo's, first says "*The language of nature is mathematics*".[3]

Science and technology changed radically after Alexander the Great's campaigns in Egypt and Asia. They led to a universal culture which was purely Greek. As a result, what is today Western Civilization emerged. Alexander the Great, with the appropriate training from giants such as Aristotle and Menaichmus, conquers the then Ecumene and at the same time as the

1 Heron Mech. , Definitiones C 136,13,4 Any problem and any theorem a ts from perfect a ὑτοῦ of paid parties he wants these things whenever he has them ἐν ἑα υτῷ · proposal , presentation , appointment, construction, demonstration, passage.

2 [see Heron *Terms of Geometry and Geometrics* 136.1.1 - 136.2.9

3 1623 work, "Il Saggiatore" (The Assayer), Galileo expressed this idea in the following passage: "Philosophy is written in this grand book, the universe, which stands continually open to our gaze. But it cannot be understood unless one first learns to comprehend the language and interpret the characters in which it is written. It is written in the language of mathematics, and its characters are triangles, circles, and other geometric figures, without which it is humanly impossible to understand a single word of it; without these, one is wandering about in a dark labyrinth."

goods, knowledge is also passed on, while at the same time new knowledge is produced. It is reasonable that the flourishing of Hellenistic science was named by L. Russo *The forgotten revolution*,[4] because indeed it was perhaps the most important revolution which led to today's technological civilization.

The research centres of the Hellenistic period shape Culture, Sciences and for the first time Technology based on the laws of nature. The Museum was founded on the model of the Lyceum and Plato Academy. The Library of Alexandria was founded with books from the Lyceum library that went to Alexandria from Athens [5]and established the new vast global knowledge center of the World that has been a catalyst for more than a millennium.[6] The Ptolemies attract and recruit young people from all over the Hellenic World and mainly from influential cities that have a long and successful tradition in philosophy and the sciences, such as Samos, Kos and Cyrenaic.

Trade bureaucracy contributed to this development. Bureaucracy required a huge number of literate youths, who would serve as clerks in each port, notably the huge port of Alexandria. Among the many trainee scribes, those who will be promoted up from the port to the Library and Museum of Alexandria stand out.

In the major centers of science, such as the Museum and the Libraries of Alexandria, the schools of Athens throughout time have maintained their prestige as well as their value until the beginning of the Byzantine period despite the shift of the centre of gravity of the sciences to Alexandria, Rhodes, etc. a. elite scientists, philosophers, doctors and inventors gather. Science and technology benefit from wealth (Alexandria, Rhodes) and progress. The sciences develop on the solid foundations of the pre-Socratics with the Pythagorean scientific methods, mathematics with proofs, determinism, laws of physics, harmony, symmetries and generalizations of theories and technology for the first time is based on the sciences and particularly on the laws of physics. The laws of physics allow for proper optimal design and construction.

2 Causality and the Laws of Physics

Inventing the laws of physics is a crowning achievement. Pythagoras (570 BC – 495 BC)[7] Introduces the concept of mathematical formulas to express the laws of physics as tradition

---

4 Russo, L., 2003. The forgotten revolution: how science was born in 300 BC and why it had to be reborn. Springer Science & Business Media. Irby-Massie, GL and Keyser, PT, 2002. Greek science of the Hellenistic era: a sourcebook. Psychology Press.

5 Athenaeus (I. 3 a - b)

6 Βλ. π.χ. Elmikaty, H. S. (2005). Science education: on the agenda of the library of Alexandria. Museum International, 57(1-2), 92-99, El-Abbadi, M. (2017). The Alexandria library in history. In Alexandria, real and Imagined (pp. 167-184). Routledge, Serageldin, I., 2013. Ancient Alexandria and the dawn of medical science. Global Cardiology Science & Practice, 2013(4), p.395.

7 Aetiou , *Per of likes philosophers physicists doctrines* , choices Stoviau , Pythagoras Mnisarchou Samios first philosophy to this to ṗimati you promised , *first their numbers and the symmetry the in however , Tina harmony calls* , ex of both complex elements. Sixth Empirical To *students* with p They bought *them numbers ἕlex if p anyway at first* , Mr but the ends of them are subjects of bodies , but where ? the Plato a ts Let 's see. Plutarch , Ethics , Peri Homer or Peri of life and poetry Homer :

says he refers specifically to the periodicities of the planets by which they would determine the positions of the planets. He constructs with harmony the musical Pythagorean tuning with frequency ratios of intervals with a sequence of fifths and ratios 3:2. He is referring to symmetries and harmony, he must have found that the scientist can be led to formulate more general laws of physics with symmetries, harmony and generalizations; just as theoretical physicists today predict new particles, or as chemical elements in the periodic table of chemical elements. Determinism has been perceived through experience since prehistoric times. Getting the laws of physics right is often a difficult process. The optimal formulation of the laws of physics requires the correct choice of physical variables, and physical quantities (distance, mass, etc.) and this is of capital importance. The exact determination of the appropriate mathematical formula is even more difficult, arduous, time-consuming and therefore expensive because it requires the work of scientists, philosophers and artificers who need to work for a long time.

In order to understand nature and especially to predict phenomena, man must know that:

- Natural phenomena can and are understood and interpreted in terms of nature,
- Determinism and causality rule the Cosmos, Nature
- There are laws of nature that describe, explain and even predict natural phenomena
- The laws of nature are expressed precisely using precise and appropriate mathematics,
- The laws of nature are eternal and universal, but the way these laws are approached by people from time to time in a given social and scientific environment is only an approach to reality.
- The accuracy of the laws of physics can be improved through observations, precise measurements and appropriate mathematics.
- This depends on the experimental and mathematical methods, tools and means available or mathematics developed especially.

In short, all of this is based on the Pythagorean doctrine that everything is mathematical, that is, everything can be properly understood using mathematics, which expresses the laws of physics.

A very important advance was made with the birth and development of astrophysics, and especially the branch of astrophysics we call cosmology which began when men made the first attempts to study nature from nature's point of view and leaving gods and metaphysical phenomena to edge. This began with the study of the stars, with the discussion of their nature, with the advent of astrophysics.

Philo of Alexandria (c. 20 BCE – c. 50 CE) typically mentions that the scientific and especially the research tradition was achieved with the long-term and generous contribution of the Ptolemies to the Library and Museum of Alexandria. Hero[8] and especially Philo cites as an example the research to find the mathematical formula of the torsion spring catapult, which led to the construction of excellent war machines which offered advantages to the Ptolemies, as earlier in the campaigns of Alexander the Great.

---

because Don't buy them *numbers maximum dyn amin ἔχειν* abbot and always numbers about , of th of stars the periods.

8 See *Needlework, Automation* [Heron (1996). *Automation, The art of building automata. Translated Dimitrios Kalligeropoulos. Athens: Ancient Greek Technology.*]

3 The Ultimate Invention of Proofs in Mathematics

The invention of theoretical mathematics with theorems and exact proofs, as Hero rightly argues, is of capital importance for the evolution of humanity and especially of science and technology. The foundations of theoretical proofs were laid in geometry by Thales. Mathematics progresses and evolves, becoming pure mathematics, just like the sciences. They begin practical and observational and evolve into the beauty of pure science. As Kepler emphatically says "*if all civilization were destroyed, it would be enough to save the Pythagorean theorem to be reborn*". The important Alexandrian mathematicians include Euclid, Apollonius of Perga, who studied conic sections and the greatest of all, Archimedes of Syracuse.

The first extensive and comprehensive theoretical work is that of Autolycus of Pitaneus (360; BC – 290 BC) in mathematics, kinematics and astronomy. In his two astronomical books it is the oldest book of classical Greek geometry with proofs and conclusions. They are structured with hundreds of entries with proofs. It gives the mathematical relationships for sunrise and sunset and the positions and movements of the stars during the day and year. It essentially introduces theoretical mechanics, with the rotation of the solid body. Certainly, there were other earlier works that have been lost. His works had a huge impact on Arabic science. It was translated and commented on by the most important scholars in the Islamic world, Ishaq ibn Hunayn al-Nasrani, the Christian Arabic scholar Kust ibn Lukka al-Baalbaki the leading mathematician Thabit ibn Korra and Nasir al-Din at-Tusi.

Euclid (around 350 BC - 270 BC) gathered the knowledge of geometry and created theoretical geometry, ie geometry based on theoretical proofs, with theorems and radically changed the form of mathematics. The book of *Genesis* has more editions than any other book after the Bible in all languages. His works refer to Autolycus and include theoretical optics, perspective, astronomy with scientific method, with theorems and proofs.

4 Alexander the Great and his Scientific Staff

It is worth referring to the example of the use of the sciences by Alexander the Great who taught his successors with his practice and they in turn gave the sciences their rightful place. Alexander the Great because of his scientific training from Aristotle and other scientists valued science and technology and had many scientific engineers on his staff which was a key part of the military machine. It is worth mentioning the most prominent ones.

Aristobulus Kassandreios (375 BC – 301 BC), scientist (Architect and weapon engineer) and close friend of Alexander the Great who accompanied him on his campaigns. He wrote on the military art of M. Alexander, geography, ethnology, biology, botany and zoology of Asia. The Thessalian engineer Diadis of Pella (4th century BC) also accompanied Alexander the Great on campaigns. He was a student of Thessalian Polyeidos, a military engineer of the father of Alexander the Great Philip II. He was called Diades the Sieger because of his successes with siege engines and wrote a book about it. Diades built huge mobile towers with ladders and siege rams, cranes with weights for the destruction of the walls and conquered Tyre with Alexander" (332 BC).

Olynthius the engineer, plumber and metallurgist Cratis or Krateros, was another scientist who accompanied Alexander the Great. He drained the marshes of Alexandria, contributing significantly to the construction of the city. He had relevant experience because he had contributed to the water supply and drainage of Kopais.

These scientists made many inventions and developed many important applications. Many of the military secrets of the era of Alexander the Great and the Hellenistic period have been lost, especially the rules and laws of physics for the construction of weapons, with few exceptions. Fortunately, important aspects of Archimedes' work are known to some extent.[9] Certainly enough passed to the Romans and Byzantium.

5 Scientists during the Hellenistic Period

The work of numerous scientists during the Hellenistic period is impressive. Alexander the Great's perception of the usefulness of scientists was passed on to his generals and successors after his untimely death. Generals having seen the application of science to warfare with guns and siege engines readily embraced these practices. The richness and abundance of data from around the world have enabled progress. The generous sponsorship of inspired leaders, such as the Ptolemies in Alexandria was very important. The same practice was in important cities of the Hellenistic era, from Syracuse, Rhodes, Athens, Smyrna, Antioch, and Tralles which had excellent centuries tradition of automata.

Scientists are numerous. There is mobility and communication in the Greek World of Alexander. Scientists exchange extensive letters with scientific content, with measurements, theorems, proofs, etc. It is difficult to distinguish the mathematicians from the physicists and engineers. They all used mathematics mainly for the laws of physics, for the calculations of constructions, architecture, for the construction of war machines, for trevelling and more. Let us refer to scientists less known to the general public.

Ctesivius of Alexandria (Alexandria, 285 BC Alexandria, 222 BC) is a great inventor who is justifiably considered a wizard of automation. The Spartan mathematician and engineer Agesistratus (2nd century BC), a student of Apollonius of Perga, excelled in war machines and fortifications. He designed and built the largest catapult with a massive range of 4 stages (800 m). He built many devices, such as large catapults, which he presents in his book Siege Engines. The mathematician and engineer Athenian Tacticus (1st century BC), a student of the engineer Agesistratus, wrote the book *On Machines* where he gives the history and construction of war machines. The astronomer and mathematician Theodosius of Bithynia or Theodosius of Tripoli (160 BC – 100 BC), continued the work of Autolycus on the sphere and made a clock that worked in all latitudes. Andronikos of Kyrros or Kyrristos (2nd and 1st century BC) is the well-known engineer, astronomer and architect who made the famous octagonal multi-dial huge clock (13 m height) of *Aerides* in Athens and an elaborate clock on the island of Tinos. Greek mathematicians, following the dictates of Pythagoras, are essentially all Pythagoreans in many aspects of the sciences, they love and highlight symmetry, harmony, generalization and paradoxes. A typical example is the so-called

9 Evangelos S. Stamatis , 1971, Archimedes Apanta. 4 volumes ed. TEE, Athens, Easton , R. L., & Noel , W. (2010). Infinite possibilities: Ten years of study of the Archimedes palimpsest. *Proceedings of the American Philosophical Society* , 154(1), 50-76. Netz, R., Noel, W., Tchernetska , N., Wilson, N., & Acerbi, F. (2013). The Archimedes Palimpsest. *Aestimatio : Sources and Studies in the History of Science* , *10* , 34-46.

Ostomachion[10] (or 'stomachion') with the diverse (various) theory of the transfer of the shapes from which it has been constructed. The Ostomachion, based on and new lost texts that survived in 4 Arabic and corrected by copyist's errors, and also in the book *On Stoic Objections* of Plutarch[11] prove that Archimedes' study constitutes the first scientific Combinatorial Analysis. Similarly, Apollonius in the Books of Conics presents theorems that expand perception, paradoxes, useful in solving 33D problems and finding limits. He presents the most beautiful (callista) mathematics. Greek scientists continued the progress of science during the Roman period. Menelaus of Alexandria (70 -140) also studies the (celestial) sphere. His work had a great influence on the Arabs who continued the work of Autolycus, Tripolitis and Menelaus.[12]

Archimedes. Archimedes of Syracuse. Photogravure by R. Paulussen after N. Barabino, Nicolò, 1832-1891. Thanks Wellcome collection. Reference : 572 i

10 Vafea, F., D. Kalisperis , A. Tsolomytis , 2024, Ostomachion or Stomachion , Archimedes of Syracuse , Cairo and Samos, isbn 9786180053401

11 Plutarch *On Stoic Oppositions* (1047. C.10-E.3)

12 Rashed, R., & Papadopoulos, A. (2017). *Menelaus'› Spherics‹: Early Translation and al-Māhānī/al-Harawī's Version* (Vol. 21). Walter de Gruyter GmbH & Co KG. Athanase Papadopoulos. Menelaus' Spherics in Greek and Arabic mathematics and beyond. 2023. ffhal-03993581 Athanase Papadopoulos. Menelaus' Spherics in Greek and Arabic mathematics and beyond. 2023, https://cnrs.hal.science/hal-03993581

6 Astronomy

Astronomy since the birth of civilization has given rise to many discoveries. The harmonic motions led to the formulation of the first laws of physics, namely the periodicities of the Moon, the Sun and the planets. Hellenistic astronomy continues to predict the positions of the planets with relative success using the epicycles which Kepler uses despite the introduction of his three laws of planetary orbits using conic sections. Kepler has been taught by Menaichmus (who is said to have been a teacher of Alexander) and the work by Apollonius the Perga on conic sections. The accuracy of the theory of epicycles led Fourier to formulate his theory of the same name.[13]

Eudoxus (probably born 397-390 to 345-338) was a student of Archytas, while his students were Chrysippus and the mathematician brothers Menaichmus and Deinostratos. Eudoxus was a philosopher, mathematician, astronomer (he also created an observatory in Knidos), physician, geographer, politician and legislator. He came into conflict with Plato, although they positively influenced each other. Eudoxus studied the movements of the planets, particularly their speeds. He built a model of the world as we see it from Earth. He used concentric spheres for the movements of each planet, the Sun and the Moon. This model is similar to spherical harmonics.

Aristarchus the Samian, introduces the first heliocentric theory, which was confirmed and finally imposed by Copernicus, Kepler and Newton in the early 17th century. Aristarchus measured the diameter of the Earth's shadow during a lunar eclipse and calculated that the diameter of the Earth is 2.85 times that of the Moon instead of the correct 3.67. Based on this measurement of the relative diameter of the Earth in front of the Moon and solving the related triangles, as well as the right-angled triangle of the Earth, the Sun, the Moon during the quarter of the Moon, he calculated the distances of the Earth - Sun and Moon. The results are not correct because the measurement of the right angle triangle the angle was not exactly 90 ° but 89° 51'. This small difference caused enormous error to the calculation. The measurement of the circumference of the Earth by Eratosthenes (276 BC – 194 BC) is known, who also correctly measured the distance from the Earth to the Sun. He probably used a method similar to Aristarchus. We must remember that Anaximander was the first to argue *that the Earth revolves around the center of the* Universe and the Pythagoreans were the first to dethrone the Earth from the center of the Universe.

Hipparchus of Nicaea or of Rhodes (190-120 BC), is considered by many to be the greatest Greek astronomer. Ptolemy refers to him as "the greatest lover of truth" and admires the accuracy of his measurements. Some call him the Einstein of antiquity. Hipparchus discovered the precession of the equinoxes and the 26000 year periodicity of the Earth's axis introduces trigonometry, he measures by eye the power of the stars in logarithmic climates dividing the stars into 1st, 2nd, 3rd etc. magnitude. This scale of measuring the power of the stars was made more mathematical in the 19th century by Pogson, as it is based on the Weber Fechner law. The perceived feeling, the stimulus (loudness, brightness etc) is proportional to the logarithm of the actual intensity measured with an instrument. He is the inventor of the plane astrolabe, correctly projecting the celestial sphere on the plane, improves the diopter.

13 J. Fourier, *Théorie analytique de la chaleur* (1822)

Hipparchus the Nicaeus or Rhodian. Drawing of the 19th century from an engraved seal on amethyst from the Poniatowski gem collection, proved to be a fograry.

Archimedes had built a similar instrument. This allowed the measurement of the angular extent of the sun and the moon in the sky, the measurement of their relative distance and their actual size, when the distance was measured by alternative methods by solving relative triangles or using trigonometry. He increased the accuracy of traditional astronomical instruments, the Hourglass, the Gnomon, the Heliotrope or Skiatheron, the Heliorologion, the Kathetion, Crikus (spherical astrolabe), the Solid Celestial Sphere (map of the Sky), and the Hydrohorologion.

Hipparchus wrote many books, all but one of which have been lost. " *On those borne down by weight* " probably referred to universal gravitation, certainly based on earlier notions of universal gravitation by Leucippus and Democritus. *All the stars are at the same distance or the nearest one would pull us,* says a surviving passage of the atomists, suggesting that the philosophers understand universal gravitation. The subject of the distances of the Earth, the Moon and the Sun, possibly the planets, with parallax methods, with solving triangles and trigonometric methods must have been dealt with in the two *Parallax* books of Hipparchus, as well as the book *On the sizes and distances of the Sun and the Moon.* Important was the book *On the latitudinal monthly movement of the Moon* where he would certainly present his measurements regarding the changes in the distances and the speed of the Moon. Related was the also lost book *On Eclipses of the Sun in the Seven Climates* that deals with the problem of observing a solar eclipse from the North to the South Pole of the Earth. This theme is also mentioned in the texts of the Mechanism of Antikythera.

The books *On the Constellations* and *On The Fixed Stars Compilation* would certainly give the mapping of the sky and the division into sections, the constellations. They would certainly contain an extensive table with the coordinates and magnitudes of many stars, i.e. the power of each star on a logarithmic scale. This list was used by Claudius Ptolemy and others. It is estimated that it contained around 850 stars out of the 1007 contained in a later star catalog of Claudius Ptolemy. It was last found in a palimpsest [14]of the Hipparchus catalog probably with ecliptic coordinates accurate to around 1/4 degree. Hipparchus's book *On the transition of the tropical and vernal equinoxes* certainly refers to the transition of the Earth's axis with a period of 26000 years which he discovered.

Hipparchus with a celestial sphere. Coin of the City of Nicaea. Roman times [ΙΠΠΑΡΧΟΣ ΝΙΚΑΙΕΩΝ].

He wrote many important things about calendars and the length of the year which he measured accurately, with a deviation of 7 minutes. He writes many books on how to keep the exact lunisolar calendars of the Greeks (Meton 's cycle and Octaeterida - Olympiad which is based on the octaeterida) in his books *On the size of the penumbra, On the monthly time, On the calendar months and days.* In particular, in his book *About the alignments treatise,* he would refer to the keeping of an accurate calendar and the construction of a *Parapygma,* i.e. a table like the one that the Antikythera mechanism has. Shrouds, tables of sunrises and sunsets of bright stars that existed in the Agora of every City. The painting, the parapagma, listed 36 risings or sets of some bright stars occurring at sunrise or sunset, one every 10 days (or 10 degrees in the sky). They used bright stars near the ecliptic called *decans.* Their sunrises or sunsets during the year during the sunrise or sunset of the Sun help to keep the calendar correct. Hipparchus' book *On the Twelve Signs* must also have been relevant to keeping calendars, but also to charting the sky.

His contribution to mathematics is very important. The 12 books *On the treatise on straight lines in a circle* would contain geometric and trigonometric methods that have unfortunately been lost. He is perhaps the first to conveniently project three dimensions onto the plane with a conformal representation. Hipparchus' method of projection has since produced the accurate, easy-to-use flat astrolabes that have enabled safer navigation, accurate mapping,

14 Gysembergh, V., J. Williams, P., & Zingg, E. (2022). New evidence for Hipparchus' Star Catalogue revealed by multispectral imaging. *Journal for the History of Astronomy*, *53*(4), 383-393

and all long-distance voyages. The contribution of astronomy and geometry is very important for the birth of cartography and geography.

He also wrote books with commentaries and reviews such as *On Aratos and Eudoxus phenomena,* which is the only book of his that survived, To *Eratosthenes and the things said in his geography* and the book *To the Elite.*

He is considered the first to divide the circles of these astronomical instruments into 360 degrees, he is the first to construct an accurate celestial sphere, with sidereal coordinates (ecliptic coordinates), with parallels and meridians of the sky, possibly improving an earlier celestial sphere of the also most important mathematician and astronomer Good luck.

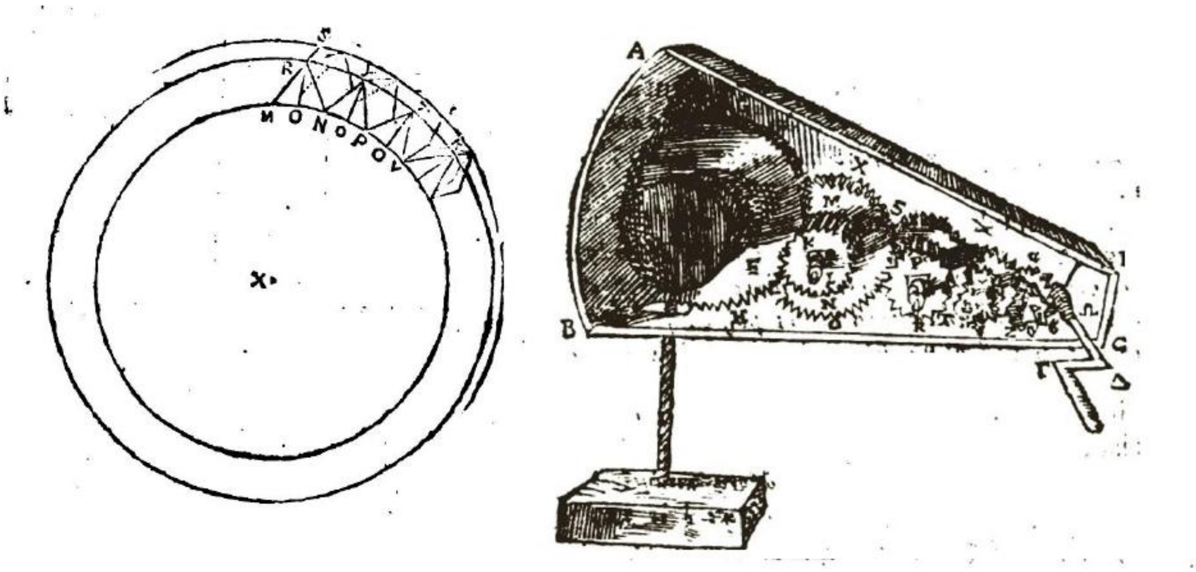
Greek scientists continued their work during the Roman period, but the sciences gradually declined. Claudius Ptolemy is a brilliant scientist who was involved in the transmission of knowledge to the Romans and then to Islam and the West. Nikomachos Gerasenos who lived around 60-120 AD acted in the same way. is a very important mathematician who studied integers and harmonics. Nikomachos conveys to us the legendary observation of Pythagoras who, as he heard blacksmiths hitting the anvil with hammers, was led to the musical scale and the theory of the Music of the Spheres, i.e. to the resonances of the Sun, Earth, Moon and planets. It is worth mentioning that these resonances are the bases of the traditional lunisolar calendars such as the octeteris, the cycle of Meton, Callippus etc.. Some such cycles, cosmic resonances, were known from prehistoric times. These resonances exist in the gears of the Antikythera Mechanism, while two completely unresponsive ones of 462 and 442 years old are mentioned in the manual of the Mechanism.

7 Astrophysics

Astrophysics was born from the pre-Socratic philosophers and naturally continued during the Hellenistic period. It is certain that mankind has had the opportunity to see passing comets up close, but also to examine meteorites that have fallen to Earth. Aristotle accurately describes the fall of a meteorite which changed course as it released gases asymmetrically and in fact the shock wave caused the earthquake of Achaia, but also a tsunami. Such observations led to the correct understanding that stars are concentrations of hot gases.

The birth of the philosophy of physiology, based on a new interpretation of Aristotle's references to comets, winds and earthquakes based on physics and a working hypothesis that humans have been led to develop astrophysics, the idea that the universe can be understood in terms of nature, of himself (and not in terms of the powers or will of the gods), in terms of observations of comets and meteorites falling to Earth. Philosophers studied the appearance of comets that pass very close to the Earth, realized that they contain volatile material, and generalized that stars are made of condensed hot gases, thus giving birth to Physiology¸ or in modern terms physics, science in general, and with it the birth of philosophy.

During the Hellenistic period, the Epicureans, the Stoics and the Skeptics, are collectively known Hellenistic philosophical currents that also dealt with physics and astrophysics, logic. The Epicureans developed the concepts of Leucippus and Democritus about indivisible atoms. Neoplatonism, from the 3rd century AD. until the 6th century AD continues the Greek philosophy and passes it on to other cultures. The Romans did not pay much attention to astrophysics and the pure sciences or theoretical mathematics.

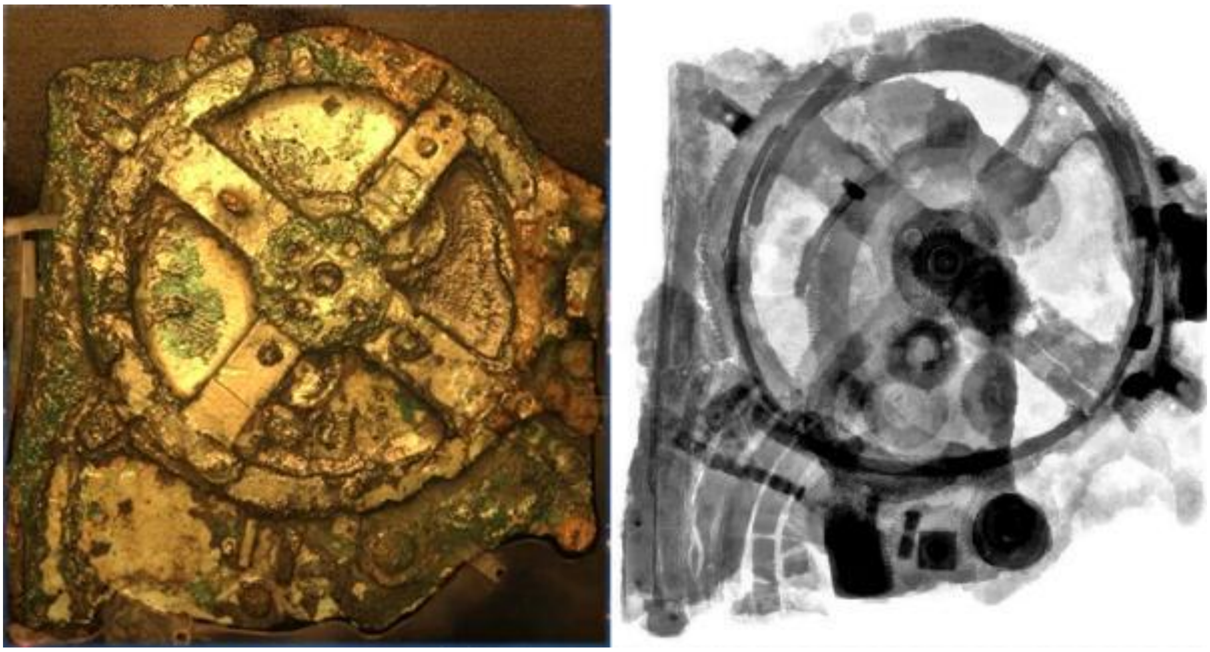


Design of gear, construction of complex machine with gears. Latin edition of Pappos *Synagogue,* 8th book.

8 Automata

Automata hold a high place in the evolution of technology and Civilization. The most famous miracle workers are the engineer Ctesivius (285-222 BC) and Heron Alexandreus (probably 10-70 AD). They and others manufacture many automatic machines, optical devices, and devices operated by compressed air. The technical terminology of Heron's books is found in the user manual of the Antikythera Mechanism. Ctesivius, is considered as the father of pneumatic mechanics, invented the hydraulic pump and the hydraulic clock, which had automatic mechanisms for showing the time. He had also developed the system of reverberating instruments (like the hydraulis), which can be considered a forerunner of automatic music. Heron had built automatons with compressed air or hydraulics, combined with ropes or animal sinews and weights. They created clocks, automata that were animals, and people, automatic doors, altars, healing toys, and weapons.
The great mathematician Pappos from Alexandria summarizes in the 8th book of his Synagogue, that the ancients call mechanics, engineers, or "miracle workers" who construct automatic planetariums, which work with fluids. Miracle workers make automata that imitate the movements of living beings. There were many similar automata with astronomical use, planetariums, since according to Pappus to be called an engineer he had to build a planetarium.

Greek engineers especially the miracle makers (automaton makers) used various techniques to create their machines. They use hydraulic systems in which the movement of water is used to operate automatic mechanisms. Water clocks and automatic doors are typical examples. They use Pneumatic Systems using air and pressure to create motion. Hero developed many air-based systems for the movement of automata and systems with Weights, Counterweights and Pulleys: These systems were used to create motion in more complex automata such as automata and moving figures. The automation of the ancient Greeks was the first form of robotics and inspired the development of technology in the following centuries, especially in the Renaissance and modern engineering.



The largest part of the Mechanism with the large sun wheel that drives the entire Mechanism, photographed and processed with the PTM method developed by Dr Tom Malzbender, HP. We do not know what the notches that appear on the four arms are. Perhaps they moved the planets, whose motion is described in the Mechanism's user manual. The Antikythera Mechanism the oldest known scientific instrument, the first computer and the oldest mechanical universe. National Archaeological Museum.

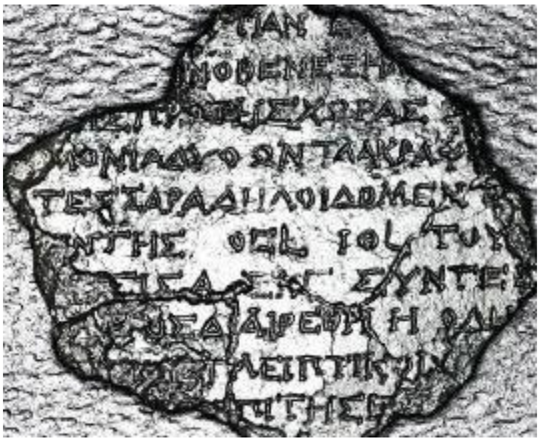
Roman automata are an important continuation of the Greek tradition in mechanisms and automated devices. Although most known automata date back to the Greek period, the Romans adopted and improved many of these technologies for practical and entertaining uses. They used automation in Theamata. Roman theatres and amphitheatres, such as the Colosseum, used automated mechanisms to lift and move props and even beasts. The machines used to bring out animals or gladiators from the Colosseum's basements were extremely complex with lifting mechanisms with pulleys and counterweights.
They continued and evolved the Hydraulic Clocks, Fountains, etc. They improved the hydraulic clocks that first appeared in the Greek tradition, some of which were equipped with automatically moving figures. Fountains in public spaces also incorporated automation using hydrokinesis with moving statues. They continued the Automatic Mechanisms in Temples to

create miracles. Temple doors could be opened and closed automatically using hydraulic or pneumatic mechanisms, linked to sacrifices made at the altars.
Important contributions are made to Automated Systems in Aqueducts which were highly developed. Automations regulate the flow, distribution and storage of water.
The Romans, although deeply influenced by the Greeks in automation technologies, placed greater emphasis on their practical applications, especially in public buildings and entertainment venues, rather than pure science which is declining.

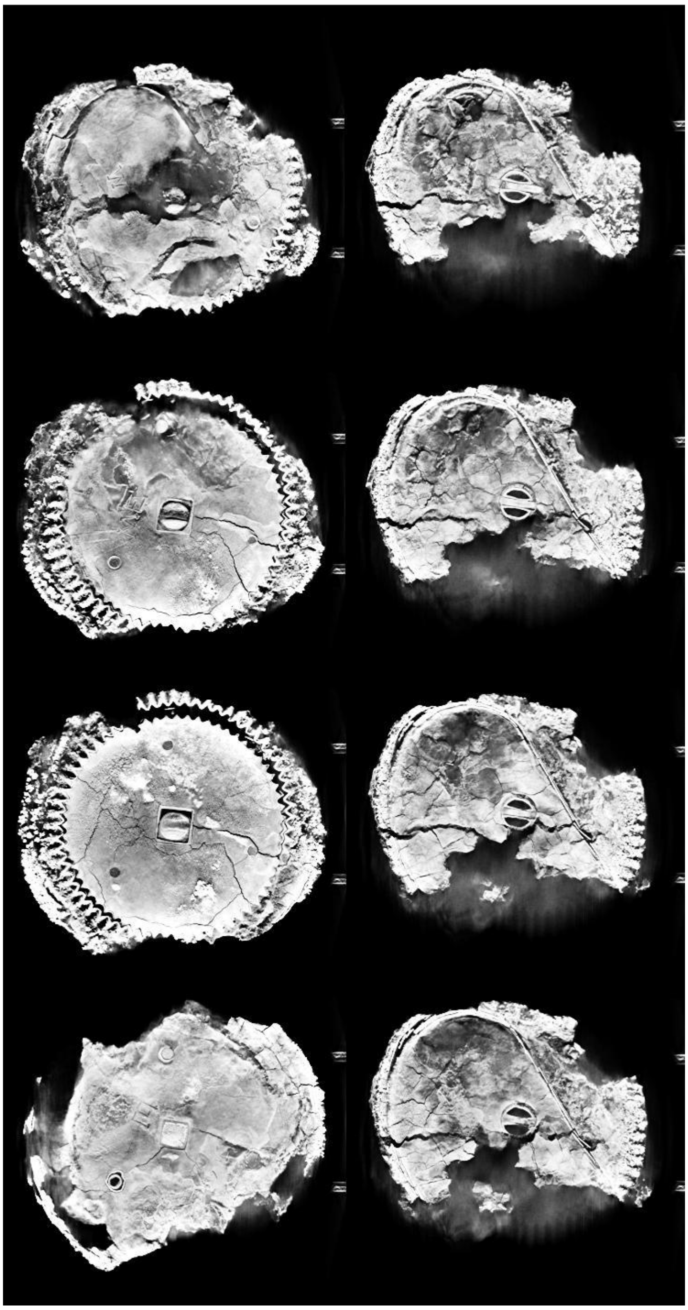
9 Antikythera Mechanism

The so-called mechanism of Antikythera, or the *pinakidion* (*tablet)* as similar devices are called by some Greek and Latin writers is certainly the best example of Greek philosophy in practice, the epitome of Pythagorean philosophy. The bits and bytes of your computer, the mathematical processing of your voice once it's recorded on your phone and before it's sent to your interlocutor has its roots in the Antikythera Mechanism.

The Olympic Games scale determines the start time of the Olympics and other games. It is based on the resonance of Earth, Moon, Sun and Venus (8-year period)



Part of the fragmented user's manual of the ancient computer. It contains the laws of physics used to predict the phases of the Moon and the eclipses. We distinguish the laws of physics that it uses to predict the phases of the Moon and the eclipses, that is, the time periods of 76 years [OCL] of Kslippus, 19 years [ΙΘL], 223 months [ΣΚΓ] and EGLYPTIKOIS [ΕΓΛΙΠΤΙΚΟΙΣ] that is, ecliptic, months during which we have eclipses.



Successive sections of the same part of the Mechanism (D). We distinguish the axis of rotation in various sections. We see in various sections the pins that join the internal gear to the lid of the almost cylindrical outer box. The studs are hollow, i.e. made of a bronze tube. The ellipsoidal object and the lamina surrounding the ellipsoidal (generalized) cylinder can also be seen in the lower right.

The Mechanism is a computer. It is a machine that accepts input data (time, latitude and longitude) and gives the result with an index on a special scale. It is programmed with gears that every two in contact perform a multiplication or division. It is a digital computer that works on the *unary numeral system.*[15] Each tooth is a bit and each gear is a Byte. The programmer uses the minimum possible number that gives a correct result. Economy of manufacture dictates prime numbers for gears with the least number of teeth possible. It is certainly an automaton and according to descriptions it is not excluded that it had automations, such as those of Archimedes' clock with automatics moving hourly, etc.

The ancient computer also has a user manual that is written on bronze plates and contains instructions for use in technical and astronomical terms. It is a densely written astronomy manual. It describes the movements of the planets. It also describes the progression of eclipses. It is reminiscent of the lost book of Hipparchus on the occurrence of eclipses in various latitudes of the Earth.

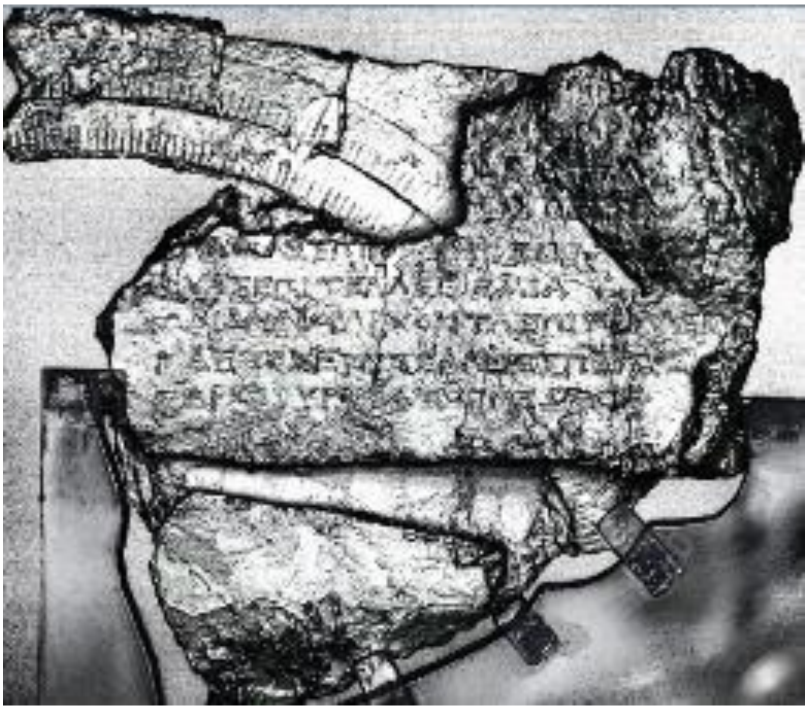
The Mechanism is a specialized astronomical computer. He calculates the positions of the Sun and the Moon, whose phase, perigee and apogee, described by Proclus. It predicts the eclipses of the Sun and the Moon. It probably also had the positions of the planets as indicated in the user manual and as described by many authors. Cicero and others describe the celestial spheres of Archimedes and Poseidon and it is clear that they were planetariums.

The Mechanism is a calendar computer that synchronizes the various lunisolar traditional calendars with each other and with the solar calendar. It has scales of the 19-year Cycle of Meton, the 76-year cycle of Callippus, the Oc(k)taetiris with the Olympic games. It also has the prediction of solar and lunar eclipses with the helical scale of Saros (duration of 223 synodic lunar months) and Exeligimos (669 months).

The Mechanism has its roots in the orientation of Ancient buildings and streets in Greece and elsewhere that go back at least to Seslkos, when man tried to predict the time of sowing, that is, to predict the weather with climatic data.

The Mechanism basically does this, as Plato describes it: *we need astronomy for agriculture and travel.* After all, these were the main uses of the Mechanism. At the same time, it served as an educational tool in a philosophical school, as an object to impress the visitors of a leader, a king who received the ambassadors of his enemies. It was extremely useful to an explorer, to any traveler, a captain, and especially to a cartographer. Greek cartographers from the time of Alexander the Great had made the best maps to the edge of Asia. The Greek geographies contain 50 cities on the eastern side of India and as far as China. Within these are included two cities of Emporia, Greek sea-stations with good harbors, and a city called Byzantion, which indeed resembles the City, with a strait between Asia and an island and a gulf like the Horn. The detailed descriptions of distances, conditions, inhabitants and their habits, include many islands of Southeast Asia, Indonesia, Sumatra, Malaysia, Borneo, Java, Papua, etc. Cartographers certainly used devices similar to the Pinakidius, the Antikythera Mechanism. The classical method considered to be based on measurements of geographic coordinates during eclipses would require thousands of expeditions by skilled astronomers and take thousands of years.

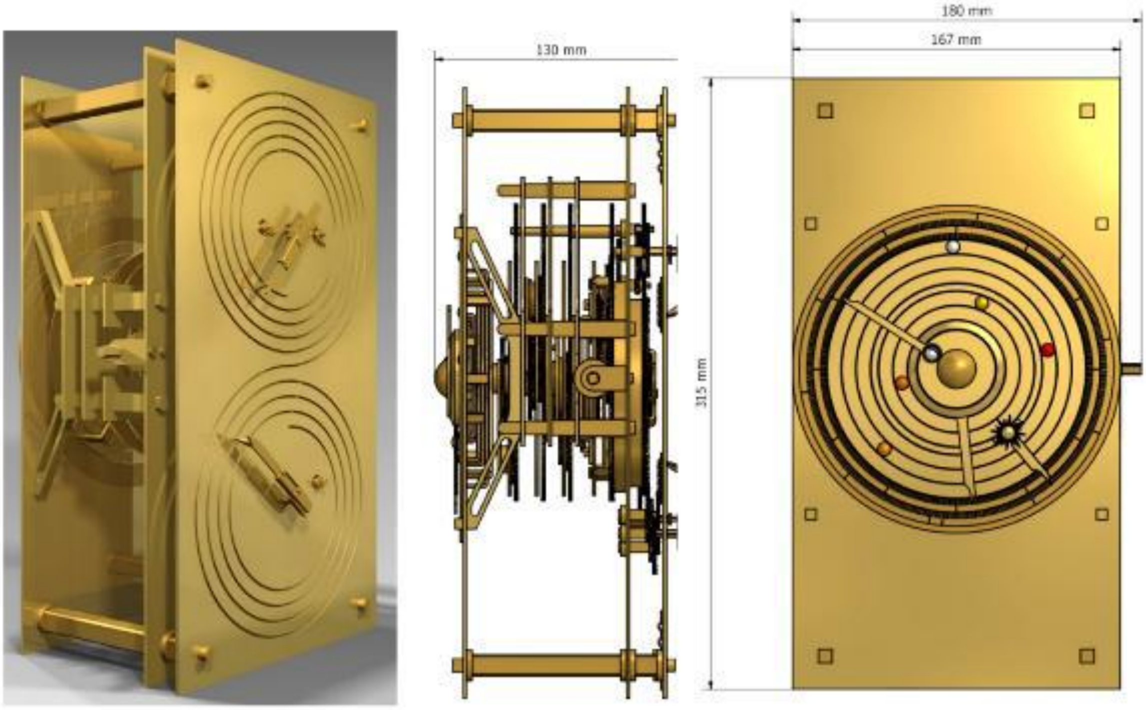
[15] In the unique numbering system each number is symbolized by repeating a character the corresponding number of times. The number *N* is represented by *N* repeating symbols next to each other. The teeth of each gear in the Mechanism case. For example the numbers 1, 2, 3, 5, 10 are respectively represented as Λ, LL, LLLL, LLLLLL, LLLLLLLLLLL, etc. We have found this system in Cycladic vases of the 4th/3rd millennium BC.



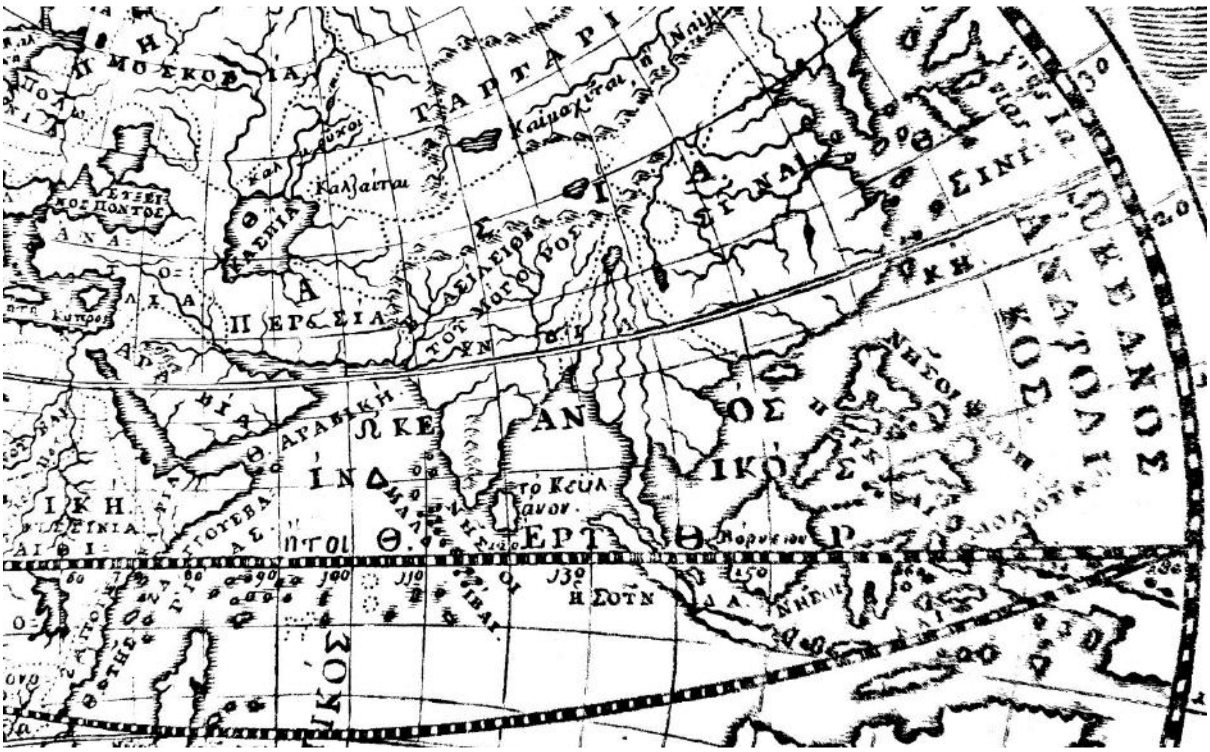
Part of the Mechanism with the scales of the zodiac and the year divided into months. Part of the computer manual can be seen that tells how to know what day of the year we have based on the rising of the stars along with the Sun. photographed and edited with the PTM method developed by Dr Tom Malzbender, HP.

The last working model of the Antikythera Mechanism that we built is an astronomical clock (Proclus says that the Tables " *show the motion of the Sun continuously* " and the definition of time according to Plato and Aristotle: *time or the motion of the Sun.* Therefore the tables were also watches.

The study and construction team of the Antikythera Mechanism-based Astronomical clock-planetarium was gradually formed in 2018, after two exhibitions of the Antikythera Mechanism that I did in Mexico. It is a collaboration between the National and Kapodistrian University of Athens and the University of Sonora Universidad de Sonora and the Mexican monumental clock manufacturer Relojes Olvera III Generacion which has a tradition of such constructions of more than a century. The team consists of Dr Raúl Perez - Enriquez, Dr Julio César Saucedo Morales, Dr Ezequiel Rodriguez Jauregui, Dr Armando Ayala, Sr Jesus Clemente Olvera Trejo, Ing. Sr Alfredo Carmona. We built the planetarium clock based on our studies of the Antikythera Mechanism which was inaugurated in Antikythera Square (as Astronomy Square was renamed) on the campus of the University of Sonora and has since become an educational tool, landmark and tourist attraction where dozens of students and tourists from University professors. It is characteristic that the city's tourist bus now has a special stop at the Mechanism of Antikythera.

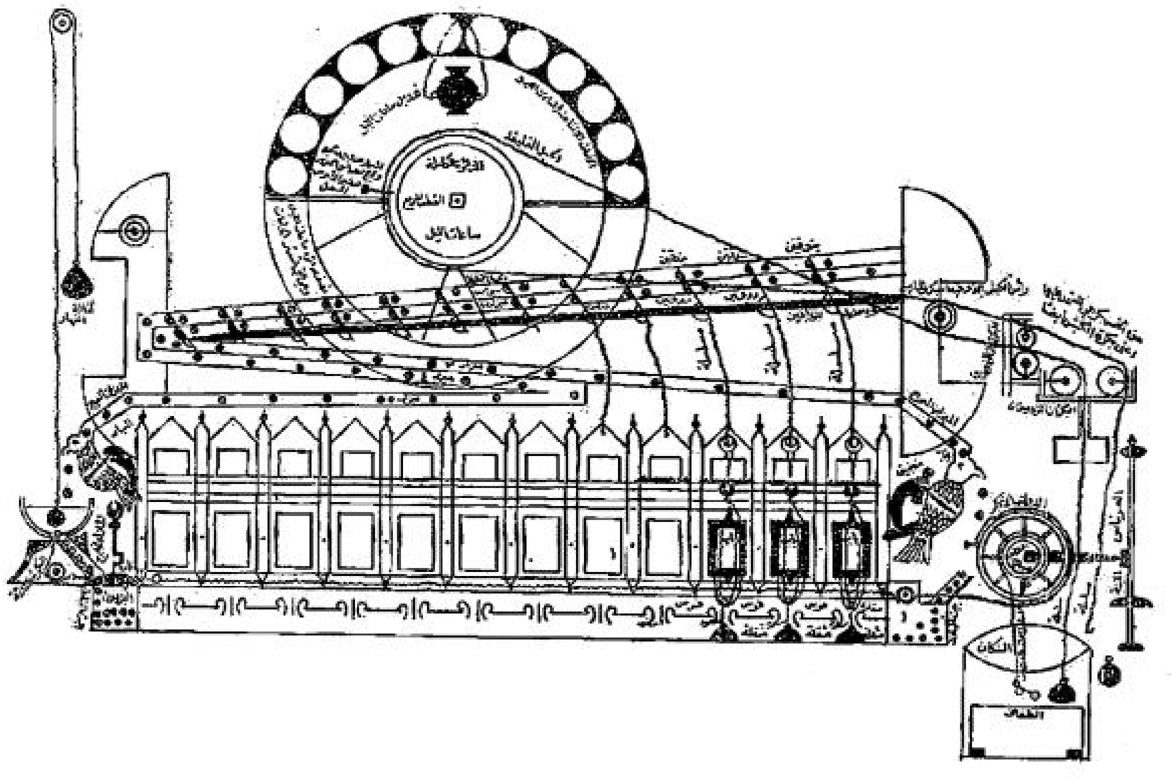


The planetarium clock we built with the University of Mexico Sonora and the *Relojes Olvera III Generacion* monumental clock Mexican Company.



Greek map of Asia 1700 (by Dionysius) printed in Paris. It is based on Ptolemy's geography.

1780s wooden calendar mechanisms from the National Archaeological Museum of Iceland.



Ridhwan 's famous watch al - Saati, described in 1203 similar to the clock of Al - Jazari based on the clock of Archimedes and Gaza of which it is a child. The movement is regulated by changing the position of a float in a water tank with a weight and counterweight system tied to a rope that wraps around a cylinder that powers the clock. Automations such as opening a door every hour are similarly driven by twelve ropes of different lengths wound around a cylinder rotating at a constant rate.

10 Archimedes and the Antikythera Mechanism

Archimedes' celestial spheres are legendary, as is his clock. Many descriptions of Archimedes' [mechanical and automatic Celestial] Sphere indicate that it was probably automatic, realistically mimicked the movements of the Sun, Moon and planets and showed their positions, i.e. it was a Planetarium. Archimedes (287-212 BC) lives in Syracuse, a Greek city of 200,000 people founded by Corinthians and Teneans half a millennium earlier. The most important Roman philosopher, Cicero, calls Syracuse a beautiful and oppressive city. In Syracuse under the tyrant Dionysius (two centuries before Archimedes), the sciences, technology applied to weapons and ships were cultivated because Sicily faced a major threat from North Africa, from the Carthaginians and Tunisians. Archimedes was taught a lot by his father, the mathematician and astronomer Pheidias. Archimedes' work in mathematics is unparalleled.

Archimedes is also a very important astronomer. He had built many astronomical instruments and clocks. Many Arabic manuscripts of the Middle Ages, Arab scholars, such as the Banu Musa, Al-Jazari, and other engineers, mathematicians, and astronomers had studied the works of Archimedes and other ancient Greek scientists, further developing these technologies. These manuscripts describe in detail the techniques used to create automations, indicating that Archimedes had reached a high level of understanding of hydraulic and mechanical systems. The automatic clock attributed to Archimedes seems to have aimed not only to measure time, but also to offer impressive spectacles through moving forms and complex mechanisms. This is consistent with the more general use of automata of that period, both for decorative and practical purposes. He had also measured the angular diameter of the Sun.

King Hieron convinces Archimedes to turn to practical applications as well, to help crucially in the defense of the city. Archimedes had built catapults that threw 270 kg stones. Archimedes built a machine that could shoot projectiles (iron arrows or stones) in succession, making it essentially an ancient machine gun. He made cranes with grapples, metal arms, [" Iron Hands" or "Grapples".] and destroyed the ships of the Romans besieging the city by smashing them against the rocks, holding them by meteors, spinning them, or throwing leaden missiles. The most important achievement of the Syracuse mathematician is considered to be the burning of the Roman fleet using the invention of an array of many hexagonal mirrors. The mirrors were adjustable with the possibility of rotation around two axes, so that they focused as was optimal. Hence the inventor of the mirror arrangement that NASA is putting on the new James Space Telescope Webb (and many others in recent decades) is Archimedes. Surely the space telescope should be named Archimedes. Archimedes' machines left a deep mark on the evolution of war technology.

In the Byzantine period, Procopius describes the Greek clock of Gaza which is a mechanical clock, in Gaza operating during the Byzantine period. In his work "On Buildings", he records various public works built under the patronage of the emperor Justinian. Among these works, the Gaza Clock is included. This clock is referred to as a complex automatic mechanism, placed in a central place in Gaza City. Its technology was based on ancient Greek knowledge of mechanics, physics, astronomy and automata. This knowledge evolved during the Byzantine period. These clocks were often combined with moving statues or other spectacular machines, and served as public instruments for measuring time. The manufacture of such clocks testifies to the technological progress of the time, as well as the Byzantines' attempt to improve public life by introducing useful and impressive mechanisms. These watches were also symbolic, as they demonstrated the power and technological superiority of the empire. The Gaza clock is an important example of the continuity of technology from antiquity to the Byzantine period, with influences from Greek inventors such as Archimedes. Similar is the Damascus clock of which there is also a design that seems to have been made like the automatic theaters of the Greeks.

11 The Romans' view of Science

The mathematician Pappos Alexandreus (290-350 AD), during the Roman era, works in the Library of Alexandria and writes an extensive work of mathematics contains theorems for the construction and use of gears with which mathematical operations are also performed. These theorems were used to construct the Antikythera Mechanism and with them we can make the necessary mathematical calculations for the movement of the Sun, the Moon and the planets.

The Romans fear science because they do not understand it and fear its power. Diocletian (284-305 AD) is the first emperor to ban [16]mathematics, astronomy and chemistry because he fears that with science the Greeks could gain power and expel the Romans. This went on for centuries. [17]The anti-scientific work culminated with Theodosius (372-395), who closed the philosophical schools.

Despite persecution in various places and at times, science survives and at times progress continues in the Hellenized Roman Empire (Byzantium). In particular, the tradition of automation continues and flourishes in Tralleis, where Anthemius (474 - 534) the constructor, architect, mathematician and physicist, was born and trained. The most important representative of the Greek spirit in science during the Roman period is John Philoponus (490-570 AD), who works in the Library of Alexandria, and who introduces concepts of modern physics, such as inertia and momentum. Many others successfully carry on the tradition after these giants on whom all science in the West rested; as Newton also writes, it rests on the shoulders of giants.

Science, mathematics, medicine and architecture passed on in Islam and later on in the West, after the fall of Byzantium and due to the llarge number of the Greek philosophers that fled to Europe, together with their libraries.

Thanks

I express my thanks to the organizers of the 3rd Conference of Ancient Greek and Byzantine Technology, Professor Mr. Theodosios Tassios, Professor Mrs. C. Palyvou and Mrs. Anthi Gorou and colleagues.

The original study of the Antikythera Mechanism was funded by the John F. Kostopoulos Foundation to which we express our gratitude for the grant of our research, without which we could not have carried out our studies. Many thanks to Leverhulme Trust for also generously sponsoring the main and key start-up phase of the study. Special thanks are also due to the

16 Νομος Διοκλητιανού You code Gregoriani , liber 14 , Tit. of evil deeds and manicJuvis , 6.)

17 Berthelot, M., 1885. *Les origines de l'alchimie.* G. Steinheil

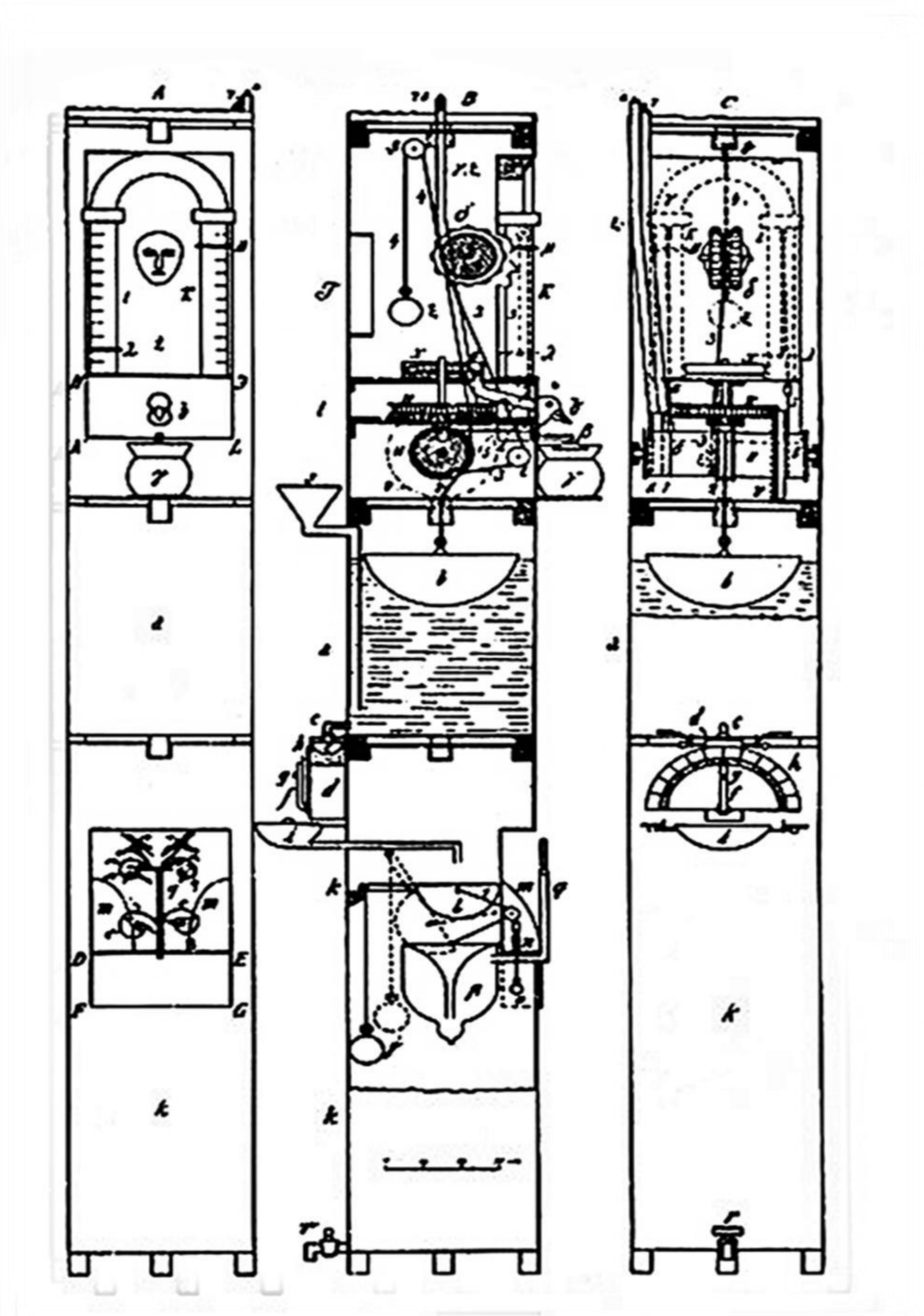
Alexander S. Onassis Foundation for a NASA exhibition grant to JF Kennedy Space Center at Canaveral. At the Ogden Foundation Trust, at The Institute of Physics (UK) we owe thanks for the ten exhibitions and talks we held with the assistance of the University of Birmingham in England. I also owe thanks to UNESCO in Paris, Uppsala University, Toulouse Observatory, the Cosmonaut Training Center of Russia, the Science Festival of Russia, the State Museum of Architecture in Moscow, the Athens Science Festival, the Mediterranean Science Festival, the Thessaloniki, Drexel University, Stonehill College, the Harvard Center for Astrophysics of Harvard University, Tufts University, Moscow State University Lomonosov, University of Cyprus, European University of Cyprus, State Museum of Architecture Moscow, Attica Region. Many thanks are due to the State Scholarship Foundation and three Grundtvig programs that contributed to the dissemination of the results of our study abroad.

Many thanks to Images First Ltd and especially the technical assistance of X- Tek Systems, now owned by Nikon Metrology, HP, Volume Graphics, MIET and NBG. We express many thanks to the National and Kapodistrian University of Athens, the Ministry of Culture, the then Deputy Minister of Culture Mr. Petros Tatoulis, the National Archaeological Museum, the National Archaeological Museum of Iceland, the Archaeological Museum of Piraeus, the Archaeological Museum of Rhodes, the Archaeological Museum of Chania, the Archaeological Museum of Heraklion and their staff.

This study was carried out in collaboration with many friends and colleagues. I owe many thanks to the professors Mr. I. Seiradakis, Mr. M. Edmunds, Dr. Mr. T. Freeth, Mr. I. Bitsakis, Professor Mr. Manos Roumeliotis, Dr. E. Magou, without whose encouragement I would not have begin the study of the Antikythera Mechanism, Ms. M. Zafiropoulou, Mr. Roger Hadland, Mr. Andrew Ramsey, Mr. David Bate, Mr. Martin Allen, Mr. Alan Crawley, Mr. Peter Hockley, Mr. A. Ray, Dr. Tom Malzbender, Mr. Dan Gelb, Mr. Bill Ambrisco, Mr. C. Reinhart, Dr. Agamemnon Tselikas and his colleagues, Dr. Mr. Haris Kritzas, Mr. Dionysis Kriaris, Mr. Ger. Makri and associates, Ms. Antigoni and associates (EAM), Dr. Magdalini Anastasiou, Mr. Ilias Gourtsogiannis, Professor Ms. Kyriakos Efstathiou, Professor Ms. Maro Papathanasiou, Mr. G. Henriksson, the late Christos Lazos, the late Vangelis Spandagos, the lecturer Mrs. Maria Pavlidou for the 10 exhibitions and lectures we held in England, lecturer Mrs. Emilia Smyrlis, Mrs. Lisa Mandaliu-Stadiati Lykopantis, Mrs. Flora Vafea, Mrs. Angeliki Simosi and the collaborators of the Marine Antiquities Tax Office, Professor Maro Papathanasiou for extensive fruitful discussions.

Professor Mr. Brendan Foley, Mrs. Leonida Gusev, the late professor Mrs. Olga Zinovieva, Mrs. Larisa Bakulina, Mr. N. I. Georgakello, the late Dion. Simopoulos, the late professor M. Mikrogiannakis, professor Mr. Kostas Triantafyllidis, professor Mr. Stratos Theodosiou, professor Mr. Manos Danezi. Ms. Katerina Paliou, Dr. Ms. Mina Tsikritsi, Dr. Ms. Dimitris Tsikritsi, Mr. Pan. Fildisi, the members of the Board of Directors of the Union of Greek Physicists. Special thanks to Ms. E. Saradea for the wonderful realistic portraits of the ancient philosophers that she created for the benefit of all of us and allows us to use in exhibitions, speeches and books.

Special thanks to Dr Potitsa Grigorakou for urging me to study science at Hellenistic times and several discussions on the subject.



Archimedes clock. The Antikythera Mechanism probably works in a similar way with weight sna counter weights regulated by a float and water. E. Stamatis, Archimedes Works, ed. TEE

Bibliography

Ancient Greek and some Latin texts, which refer mainly to astronomy and technology, Pythagoras, Plato, Thallus, Anaximander, Anaximenes, Archimedes, Hipparchus, Aristotle, Proclus, Plutarch, Hero, Theona, Euclid, Pappus, K. Ptolemy, Diodorus Sicilian, Cicero, in various editions, including Thesaurus Linguae Graecae and other sources.

Aristoteles, Metaphysica, Bekker.

Cartwright, J.H.E., González, D.L. & Piro, O. Dynamical Systems, Celestial Mechanics, and Music: Pythagoras Revisited. Math Intelligencer 43, 25–39 2021. https://doi.org/10.1007/s00283-020-10025-x

Daly, Lloyd W. 1950 Roman Study Abroad, The American Journal of Philology, 1950, Vol. 71, No. 1 40-58

Dimitrakoudis, S., Papaspyrou, P., Petoussis, V., & Moussas, X. 2006. Archaic artifacts resembling celestial spheres. Mediterranean Archaeology & Archaeometry, 6, 93-99.

Freeth, T., Y Bitsakis, X Moussas, J H Seiradakis, A Tselikas, H Mangou, M Zafeiropoulou, R Hadland, D Bate, A Ramsey, M Allen, A Crawley, P Hockley, T Malzbender, D Gelb, W Ambrisco, M G Edmunds, 2006. Decoding the ancient Greek astronomical calculator known as the Antikythera Mechanism. Nature, 4447119, 587-591.

Heath, T. L., 1932, 1981 Greek Astronomy, Dover Publications, New York

Heath, T. L., 2001 A History of Greek Mathematics.V. I, V. II, Dover Publications, New York

Heath, T.L., 1981 Aristarhus of Samos, the Ancient Copernicus, Dover Publications, New York

Moussas, X. 2009. The Antikythera Mechanism: The oldest mechanical universe in its scientific milieu. Proceedings of the International Astronomical Union, 5S260:135-148.

Moussas, X. 2011 and 2012 2nd ed. Antikythera Mechanism, PINAX tablet the first computer and mechanical Cosmos in Greek, Ed. Hellenic Physical Union, Athens, Greece.

Moussas, X. 2014 The Antikythera Mechanism: The Oldest Computer and Mechanical Cosmos. School of Physics and Astronomy, University of Birmingham, ISBN 978-0-7044-2845-4;

Moussas, X. 2014. Early Greek astrophysics: the foundations of modern science and technology. American Journal of Space Science, 12, 129.

Moussas, X. 2018 Antikythera Mechanism, the oldest mechanical Universe in Greek, Canto Mediterraneo, Athens, Greece.

Moussas, X. 2019 Antikythera Mechanism as evidence for Hellenistic technology excellence. In Hellenistic Alexandria: Celebrating 24 Centuries–Papers presented at the conference held on December 13–15 2017 at Acropolis Museum, Athens p. 209. Archaeopress Publishing Ltd].

Moussas, X. 2023, the History and Prehistory of Astronomy and Astrophysics. Under preparation.

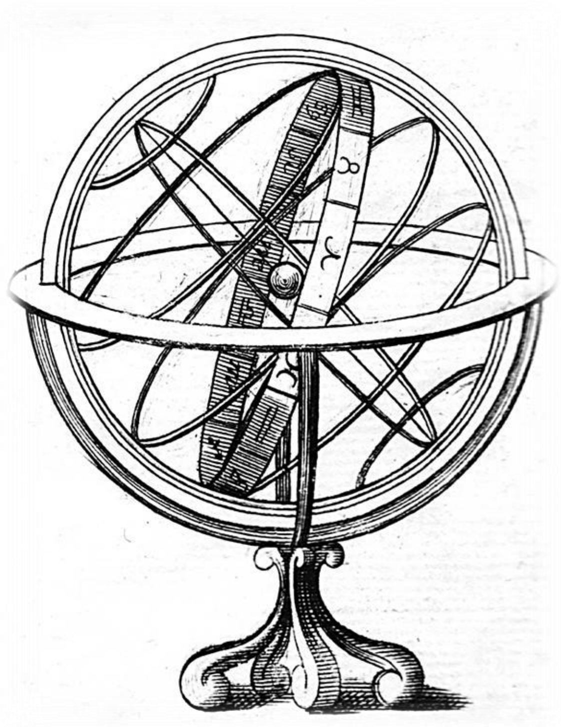
Moussas, X. 2024, *the History and Prehistory of Astronomy and Astrophysics*. In preparation.

Moussas, Xenophon, 2024 *The Earliest Computer, The Mechanism Of Antikythera, The Greatest Wonder of the Ancients*, Athens in preparation

Moussas, X., et al 2009. The gears of the Antikythera Mechanism: an educational pathfinder to the solar system. Proceedings of the International Astronomical Union, 5S260.

Nonnus Epic., Dionysiaca

Papathanassiou, M. 2017. Orphica. Orphism - hymns of Orpheus, K. S. Chassapis, Cosmoware, Athens, isbn 978-960-7596-24-6.
Papathanassiou, M. K. 2008. Homeric calendar and Helios charioteer. Science and Technology in Homeric Epics, 6, 357.
Spyridis, Char. 2014, *Plato's Theory of Everything*, National and Kapodistrian University of Athens.
Tsikritsis M., Moussas, X. Tsikritsis, D., 2015 Evidence of Astronomical and Mathematical knowledge and Calendars during the early Helladic era in Aegean “frying pan” vessels, Mediterranean Archaeology and Archaeometry, 15, 2.
Tsikritsis, M., E. Theodossiou, V. N. Manimanis, P. Mantarakis, and D. Tsikritsis. 2013 A *Minoan Eclipse Calculator*, Mediterranean Archaeology & Archaeometry 13:1;
Wisconsin Lutheran College, Roman Laws And Letters, https://www.fourthcentury.com/imperial-laws-chart/



Celestial sphere, Spherical Astrolabe, c 1700.

ΑΙΓΙΔΑ ΕΛΛΗΝΙΚΗ ΔΗΜΟΚΡΑΤΙΑ
Υπουργείο Πολιτισμού

ΧΟΡΗΓΟΙ AVAX COSMOTE ΤΕΕ ΤΕΧΝΙΚΟ ΕΠΙΜΕΛΗΤΗΡΙΟ ΕΛΛΑΔΑΣ ΤΕΡΝΑ ΟΜΙΛΟΣ ΓΕΚ ΤΕΡΝΑ

ΥΠΟΣΤΗΡΙΞΗ ΜΕΓΑΡΟ ΜΟΥΣΙΚΗΣ ΑΘΗΝΩΝ