

Science in City

Festival Trieste 2020 ESOF

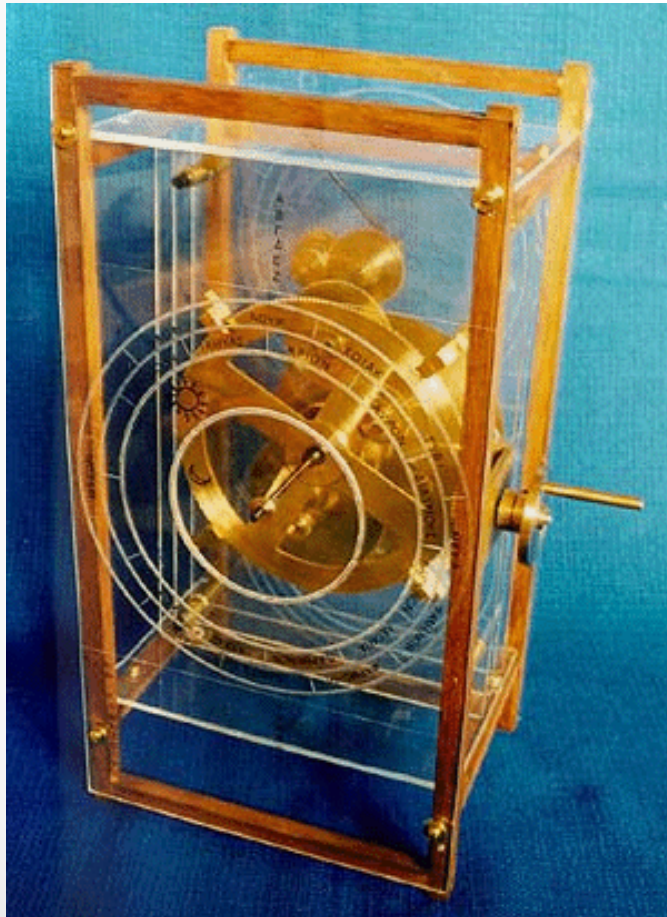
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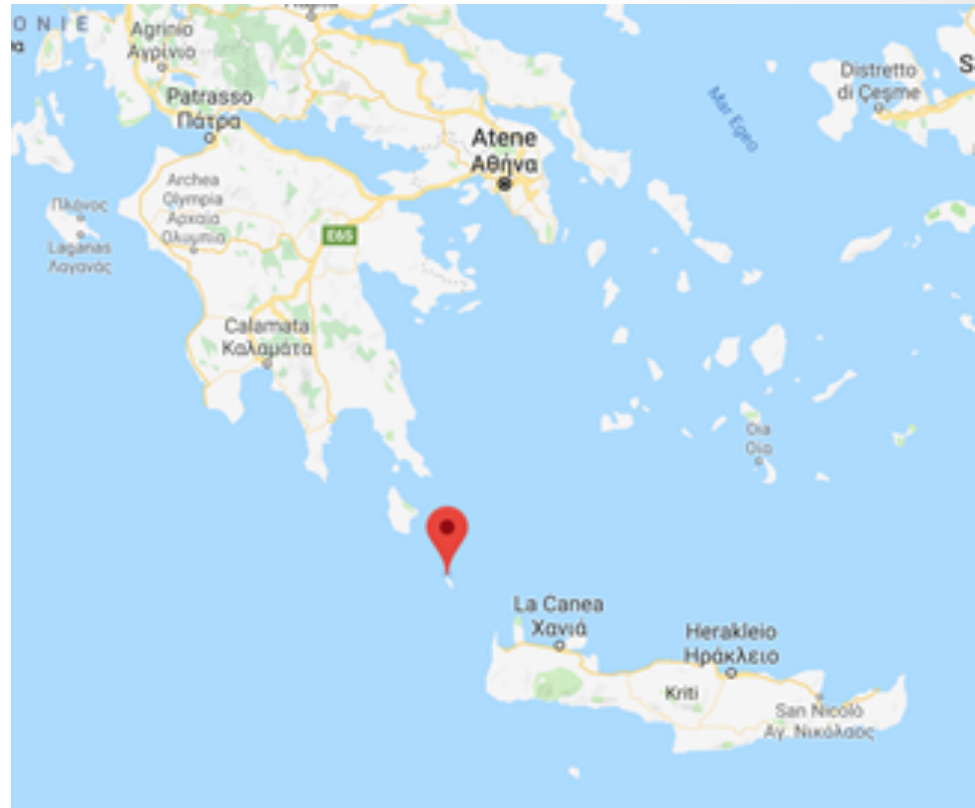
Modernity of the Antikythera Mechanism

Modern reconstructions of the mechanism



The discovery

- The 17th May 1902, the wreck of a Roman ship (first century BC) was found near the isle Antikythera (Cerigotto).
- The most interesting among the numerous evidences discovered in the ship is a «strange» mechanism which is nowadays known as Antikythera mechanism.



The discovery

- The discoverer of the mechanism was the archaeologist of the National Athens Museum. At a first glance, the mechanism appeared similar to a clock. There were many inscriptions. Some of them referred to astronomical events happened in the 77 BC.
- The mechanism consisted of 82 parts. Most of them were by copper, some by bronze.
- The mechanism was in very bad conditions. It was difficult to guess what it represented. Nonetheless, starting from its discovery, it appeared an advanced machine and some scholars arrived at thinking that it dated to a far later period than the I century BC and that it was found by chance, but that, as a matter of fact, it did not belong to the ship.

The discovery



Interpretations

- Great part of the merit for the comprehension of the mechanism is due to the archaeologist and historian of science Derek John De Solla Price (1922-1983), professor of History of Science at the Yale University. Since 1951, he begun a reconstruction of the mechanism. With a 20 years work he guessed the main features of the mechanism.
- At the beginning, he restored the mechanism.



Interpretations

- Afterwards he deciphered and translated most of the inscriptions written in the mechanism. The Sun was named several times, Venus at least once, as well as the ecliptic. Some astronomical periods used by the Greeks were named, too, in particular the Callippus cycle (period of 940 lunations) and the Metonic cycle (19 years=235 lunar months = 6940 days, luni-solar calendars). The number 223 is also present which, probably, is referred to the saros, namely the year of the eclipse composed of 223 lunar months.
- Therefore there was no doubt: the Antikythera mechanism was a sky computer!!
- In the third phase he revealed the functioning

Interpretations

- In 2008, Alexander Jones, Institute for the Study of the Ancient World, New York, understood that the names used in the mechanism were employed in the Corinthian colonies, particularly in Siracusa.
- In 2010, it has been discovered that the machine, besides the lunar phases and the motions of the planets, also calculates the eclipses and that indicated the exact dates of the Olympic and Panhellenic Games.

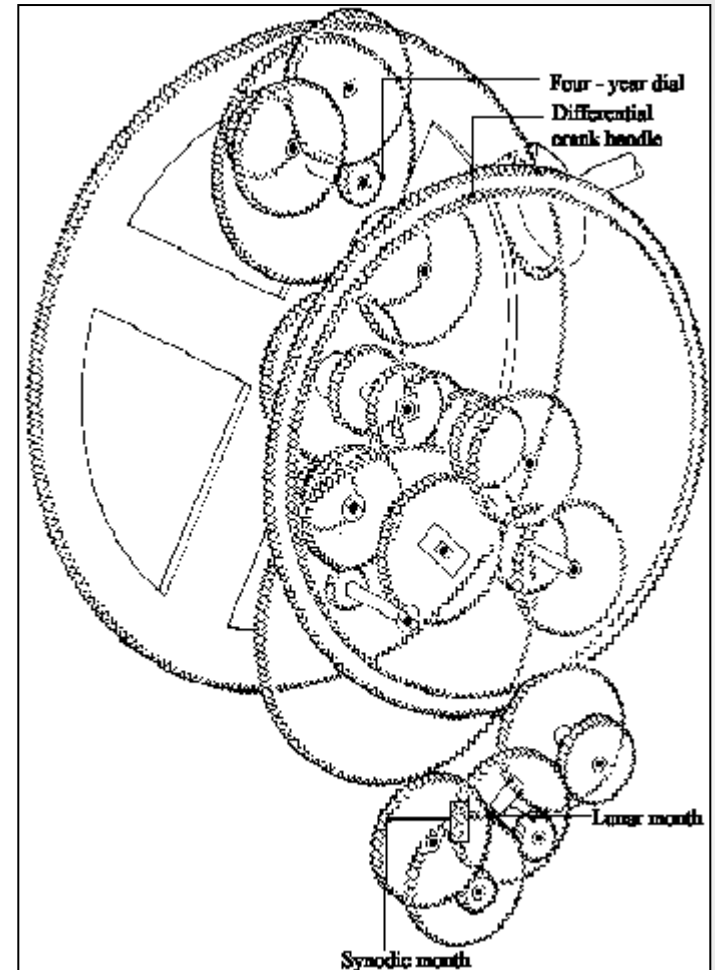


Interpretations

- Even more recently (2011), Jones has published a work on Ptolemy's *Almagest*. Actually, it is the re-edition of Olaf Pedersen's 1974 publication *A Survey of the Almagest* enriched with new notes by Jones. Several of such notes are dedicated to the Antikythera mechanism. Jones claims that it is as a philosophical guide of the sky because, thanks to this machine, we know how eclipses were foreseen one century BC and what knowledge of the sky's movements the Greeks had achieved and were able to reproduce. This is an important step towards the comprehension of Greek astronomy and technology.
- A very recent Phd dissertation (2019) tries to show that the Antikythera mechanism is, as a matter of fact, a computer of the sky which is based on **an heliocentric system** rather than on a geocentric one.
- Other scholars are less enthusiast on the importance of the mechanism.

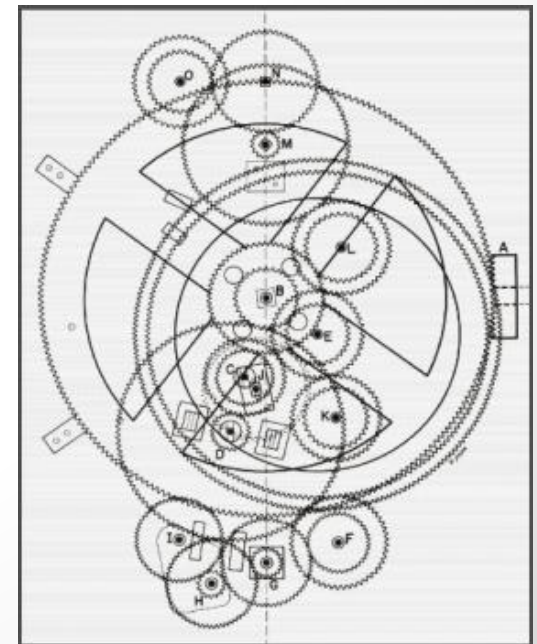
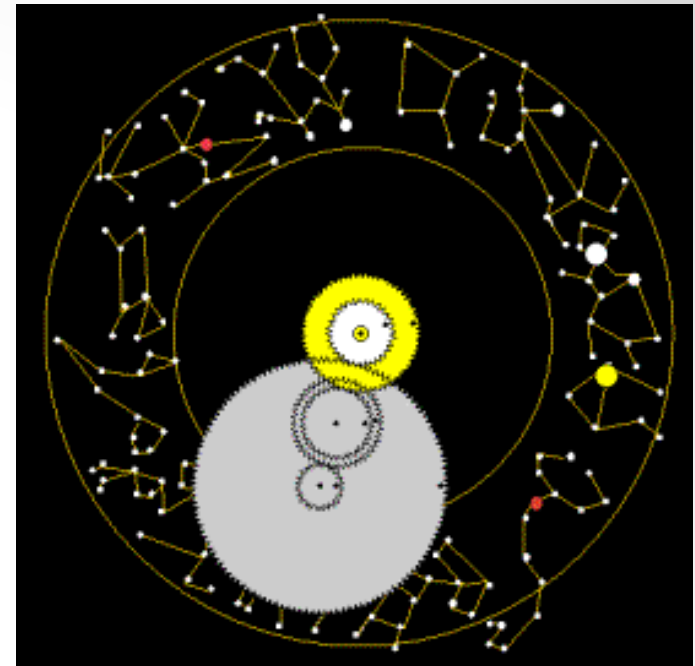
Functioning

- Derek De Solla Price argued that the whole mechanism were included in a box high around 30 cm, large 15 and profound 7,5.
- Within the box there were more than 30 cogwheels. They represented a planetary mechanism to calculate the sunrise, the lunar phases, the movements of the five planets, the equinoxes, the months and the days of the week.

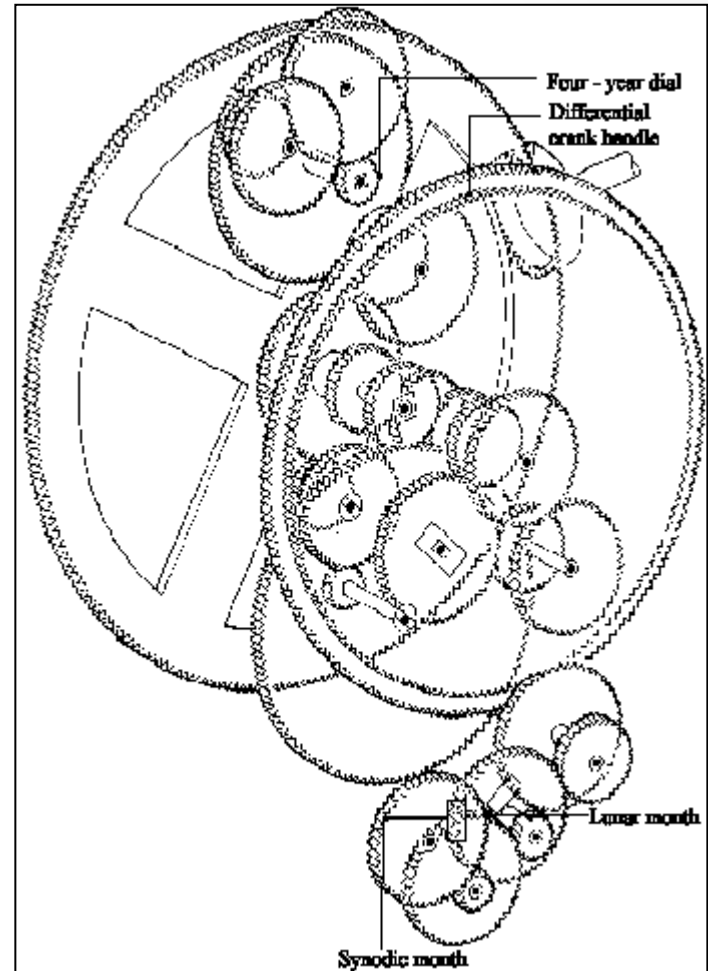
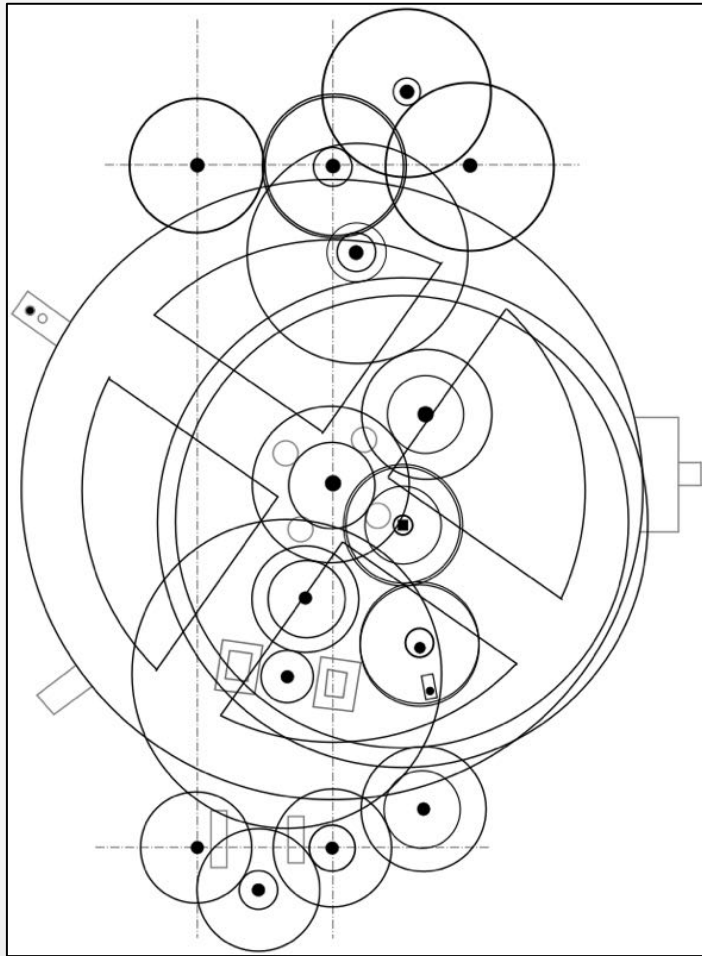


Functioning

- The principal rotating mechanism was composed of about twenty cogwheels which probably reconstructed the motion of the Moon in respect to the Sun. But there were many separated quadrants.
- The whole mechanism was constructed around a central axis which was actuated by a system of gears rotating with different velocities around different centers.
- An external handle produced the movements of the mechanism.

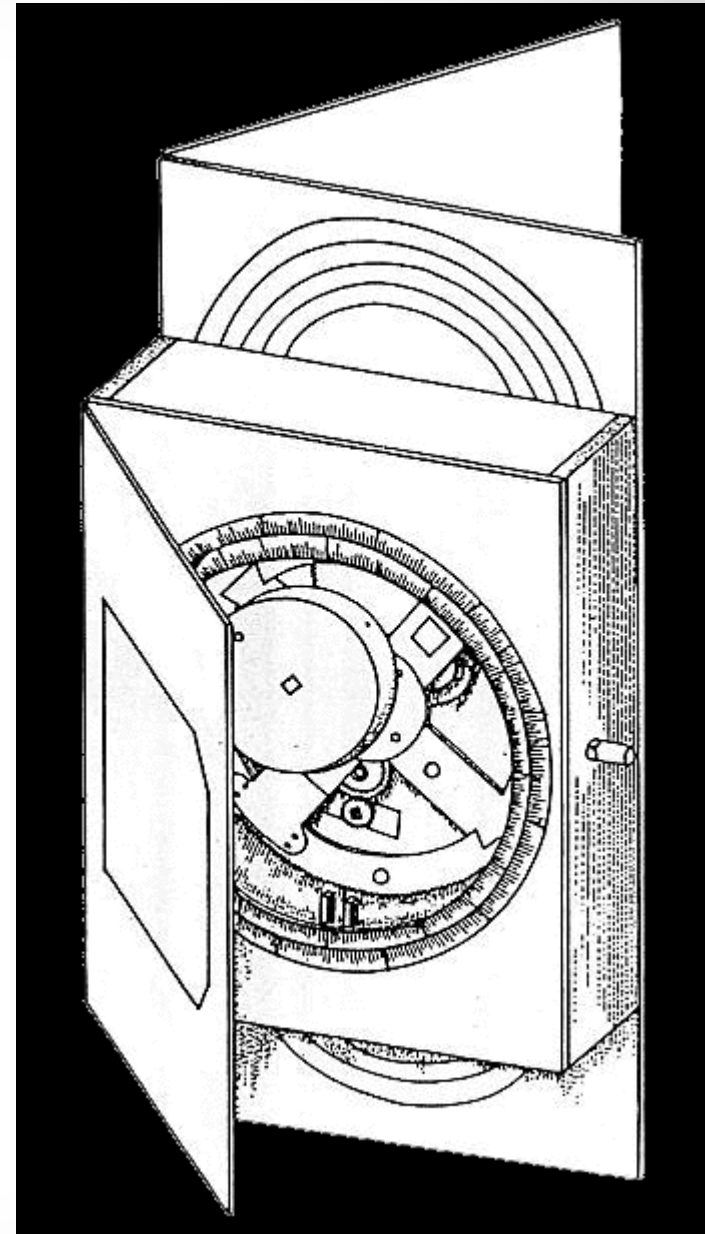


Functioning



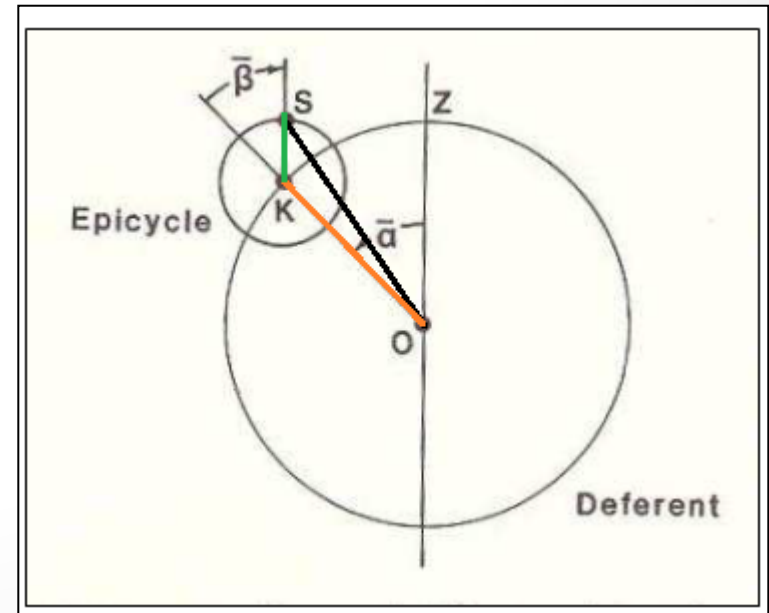
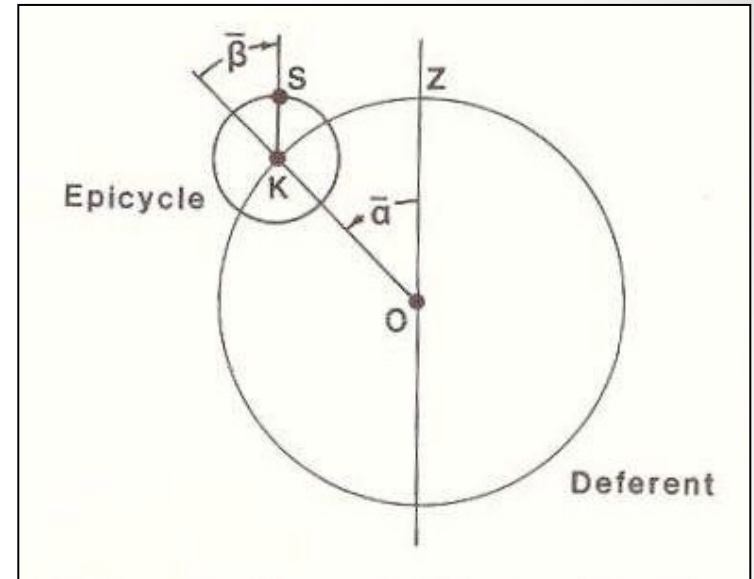
Functioning

- The handle moved actuating the different quadrants.
- For example, in a quadrant the movements of the planets were probably referred to. Many of these quadrants are damaged.



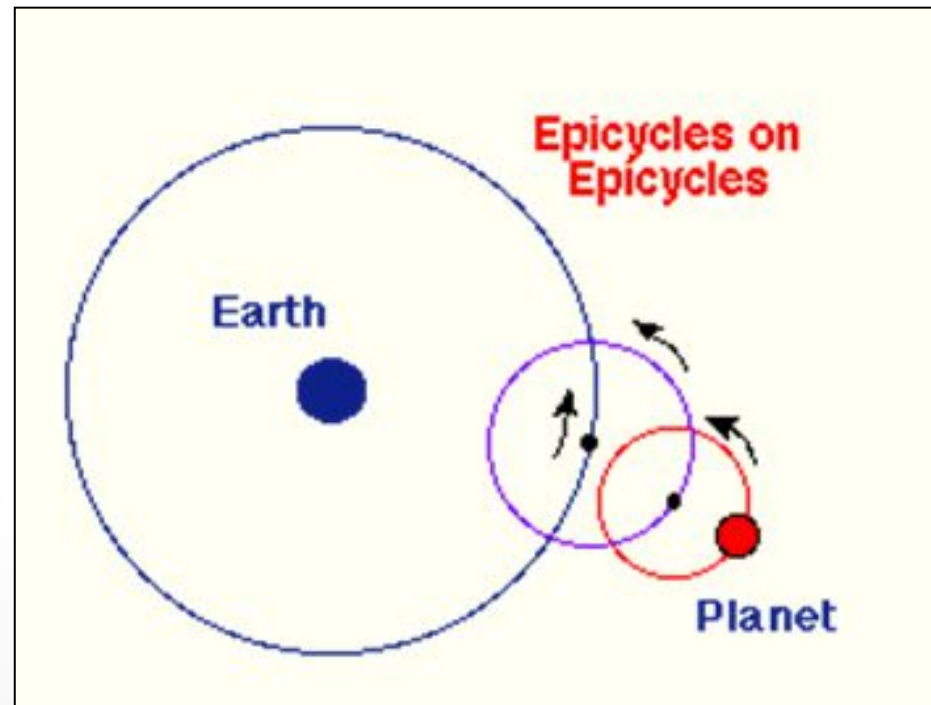
Theoretical science and technology

- The mechanism of Antikythera is strictly connected with Greek theoretical astronomy. It can be interpreted as a mechanic transcription of the main aspects of this science.
- For, Greek astronomy, and as a matter of fact, the whole astronomy until Kepler, was based on a series of mechanisms which can be seen as systems of wheels and gears.
- The systems epicycle-deferent, also considering the easiest one, that describing the motion of the Sun around the Earth, are systems of wheels and gears.



Theoretical science and technology

- These models were probably invented by Apollonius of Perge (262-190 BC), but a full coherence between models and data was obtained by the great astronomer Ipparcus of Nicea (200-120 BC) and finally improved by Ptolemy (100-175 AD).



Theoretical science and technology

- Therefore, it is not difficult to identify the conceptual root of the mechanism. However, it is not sufficient to have a theoretical science as a reference point, it is also necessary to have the technological knowledge and skill to construct such a mechanism.
- For, there is no doubt that high technical skills are necessary to construct the Antikythera machine.
- For example there is a differential, namely a mechanism which permits to obtain a rotation whose speed is equal to the sum or the difference of two rotations. Through this mechanism, it was possible to reproduce the movement of the Moon in the synodic month, the period of lunations, which is longer than the sidereal month.

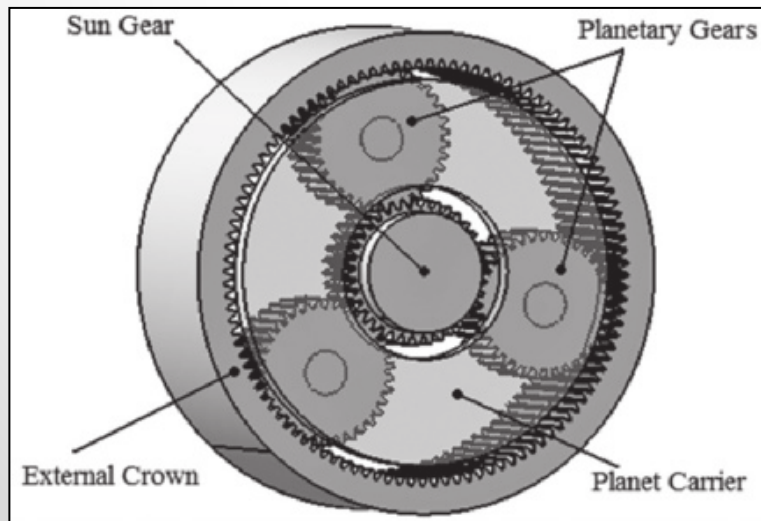
Theoretical science and technology



- Given a position of the system Moon-Earth-Sun, a synodic month=the period necessary for the Moon to assume the same position in respect to the Earth and the Sun. The lunations depend on the synodic months.
- The sidereal month=the time necessary for the Moon to rotate around the Earth by 360 degrees.
- Since the Earth rotates around the Sun, the synodic month=29d 12h 44m is longer than the sidereal month=27d 3h 43m.
- A sector of only 5 mm consists of 7 gears.

Theoretical science and technology

- The differential mechanism or epicyclic gear consists of two or n more gears such that the centres of $n-1$ gears rotate around the centre of the remaining one.
- Agostino Ramelli (1531-1610) in 1588 wrote *Le diverse et artificiose macchine del Capitano Agostino Ramelli* , o *Le varie e ingegnose macchine del capitano Agostino Ramelli*, where, among the various imagines (195) the epicyclic gear (rotismo epicicloidale) is described, too.
- The mathematical theory dates to a later period.



Theoretical science and technology

- Thence, in the first century BC there was also a good technical knowledge, not only a theoretical one.
- The fundamental question is: does this technical knowledge imply the existence of a theoretical technology, something like the modern precision engineering, or are the technological achievements obtained through an empirical, though very refined work?
- With regard to the Hellenistic science there are several lines of thought which can be summarised like this:

Theoretical science and technology

- 1) No one has doubts that the Hellenistic science reached an outstanding level. However, more or less, what nowadays we know is sufficient to obtain an almost complete picture of such a science.
- 2) It is necessary to obtain further sources and to reinterpret our sources because Hellenistic science was far more advanced and broad than we think. Only restricting to astronomy and physics, Aristarchus of Samos (310-230 BC) developed a complete heliocentric system, not only an outline. Between the end of the 19th century and the beginning of the 20th century famous scholars as Thomas Heath claimed this opinion. More recently some scholars, specifically Lucio Russo, also think that the Hellenistic scientists reached a profound knowledge of the physical law, even arriving at the universal gravitation.

Theoretical science and technology

- 3) With regard to technology, the traditional view is that a theoretical technology did not exist in Greece, whereas, according to some scholars, the Hellenistic civilization was a very modern one with a high development of technology, also a theoretical one. Not only: many other sciences as medicine were very advanced.
- My opinion: specifically as to astronomy-physics. It seems to me plausible that the Greek astronomers had developed a satisfying heliocentric system. Archimedes in the *Sand Reckoner* mentions Aristarchus (thought not sharing his opinion) and it is extremely unlikely that Archimedes had mentioned an author who constructed an outline of a system.

Theoretical science and technology

- On the other hand, I think that no system of physical causality existed in Greece. There is no trace. The evidences shown are too vague and unsatisfactory. Indirectly – of course indirectly – history of science shows how difficult was the acquisition of the concepts necessary to construct such a system.
- With regard to technology, I am not an expert. My impression is that the technological skills of the Greeks were superior than normally historiography thought. But the road to “make” Hellenistic civilization a technological civilization is still long. My impression is that the role of technology within Hellenistic civilizations is not yet completely clear.

Thank you for your attention