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DETERMINATION OF THE CELEBRATION OF THE NEXT PYTHIAN GAMES USING THE ANTIKYTHERA MECHANISM, CONSIDERING THAT THEY ARE CELEBRATED UNINTERRUPTED UNTIL TODAY

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ABSTRACT

In ancient times, games known as Pan-Hellenic [pan=all; Hellenic=Greek] games were held periodically in various places. Six of these Games were “crown” games, because the winners were rewarded with crowns. The two most important Pan-Hellenic crown Games were the Olympic and the Pythian. The discovery and decoding of the Antikythera Mechanism, the oldest extant complex geared device, constitutes confirmation of the written sources regarding the Pan-Hellenic games. A small dial within the Metonic spiral at the back site of the Mechanism displayed the celebration year of the six ancient Panhellenic crown games. Pythian Games were established in the 6th century BC. They were ranked second in importance, behind the Olympics. In contrast to the Olympics, Pythian Games also featured competitions for art and dance, which pre-dated the athletic portion of the games. Moreover, women were allowed to take part in some events. The Pythian Games were held at Apollo sanctuary in Delphi. The first celebration of the Olympic Games was held in Olympia in 776 BC, whereas the Pythian Games in Delphi in 582 BC. The games continued to be held during the Hellenistic and the Roman period. Emperor Theodosius finally decided that all worship practices, including the Games, should stop. The last Olympic Games were held in 393 AD, after a total of 293 events, lasting more than a millennium. Considering that the Pythian were celebrated two years before or after the Olympics, the last celebration of the Pythian must have taken place in 391 AD.

The timing of all major Hellenic Crown Games was set by astronomical tradition. We know from written sources that the Olympic Games (as inscribed also on the back plate of the Antikythera Mechanism) began around a full Moon in “midsummer”, suggesting the first or second month after the solstice. The purpose of this paper is to answer the question: When would the next celebration of the Pythian Games be, provided that they continued to be celebrated, non-stop, until today?

KEYWORDS: Pythian Games, Olympic Games, Pan-Hellenic Games, Delphi, Antikythera Mechanism.

1. INTRODUCTION

The Pan Hellenic [pan=all, Hellenic=Greek] holy Games were one of the basic institutions of antiquity that played a significant role in the coherence and communication between the Greek states. These Games gave the Greeks the opportunity to realize their common characteristics (language, religion, origin) and forget what separated them for a while. Greeks not only from main Greece, but also from the coasts of Pontus, the cities of Central Asia, and the colonies of South Italy and North Africa, came to watch or take part in these games. The winners enjoyed honours, privileges and, above all, the respect of their fellow citizens. Peace was so necessary for the purpose of convening people throughout Greece for the Panhellenic games, that the famous truce was established for the duration of the games. The Greek term for this is ekecheiria (*EKEXEIPIA*) (Ladia & Yannikopoulos, 2003).

The most important (Seiradakis et al., 2018; Freeth et. al., 2008; Efstathiou et. al., 2021) Pan-Hellenic

games (Fig. 1), mentioned also in the Antikythera device were:

- The Olympic games (*ΟΛΥΜΠΙΑ*), held every four years in Ancient Olympia in honour of Zeus,
- The Pythian games (*ΠΥΘΙΑ*), which took place also every four years in Delphi in honour of Apollo,
- The Isthmian games (*ΙΣΘΜΙΑ*), held every two years in the Sanctuary of Poseidon in Isthmia,
- The Nemean games (*NEMEA*), held also every two years in the Sanctuary of Zeus in Nemea,
- The Naa games (*NAA or NAIA*), which took place every four years in Dodona in honour of Zeus and
- The Halieia games (*ΑΛΙΕΙΑ*) also every four years in Rhodes.

These six Games were stephanites (“crown”) games, because the winners were rewarded with crowns-wreaths (*in Greek ΣΤΕΦΑΝΟΙ*) (see, Iversen 2020, and references therein).



Figure 1. The places where the Pan-Hellenic crown games took place.



Figure 2. Branch of olive tree (kotinos)

The two most important Pan-Hellenic crown Games were the Olympics and the Pythian (Ladia & Yannikopoulos, 2003). At the Olympic Games, *Kotinos* was established as a prize for the winners. It was a branch of the wild olive tree *Kallistefanos Elea* (Fig. 2) that grew at Olympia ("The kotinos, a crown always cut from the same old olive tree called *kallistefanos* (good to crown) that grew to the right of the opisthodomos of the temple of Zeus, was given as a prize to the winners of the Olympic Games" <https://www.thoughtco.com/panhellenic-games-ancient-greece-116597>). Respectively the winners of the Pythian Games received a wreath of bay laurel, sacred to Apollo, from the city of Tempe, in

Thessaly. Previous work on the Antikythera mechanism is summarized in various publications (Freeth et al., 2021; Seiradakis et al., 2018; Carman et al., 2012; Edmunds 2006; 2011; Freeth 2002; Liritzis 2006).

In the present article we explain the functioning of the mechanism for the determination of the Pythian games held in Delphi, if the device was used in present era.

2. The Antikythera Mechanism and the Panhellenic Games

The discovery and decoding of the Antikythera Mechanism (Seiradakis et al., 2018; Jones, 2017; National Archaeological Museum of Athens 2012; Freeth et al., 2006; Anastasiou 2014; Efstathiou, 2018; Freeth et. al., 2008; Efstathiou et. al, 2021), the oldest extant complex geared device, constitutes confirmation of the written sources regarding the Pan-Hellenic games. The Antikythera mechanism was a technologically amazing analogue computer, the 1st computer in History. It was constructed about 2200 years ago. The next mechanical calculators are built about 1500 years later. It implemented the astronomical knowledge of ancient Greeks about the motion of the Sun, the Moon and probably the planets among the stars, with astonishing accuracy, considering the anomalous orbit of the Moon, using a system of eccentric gears.

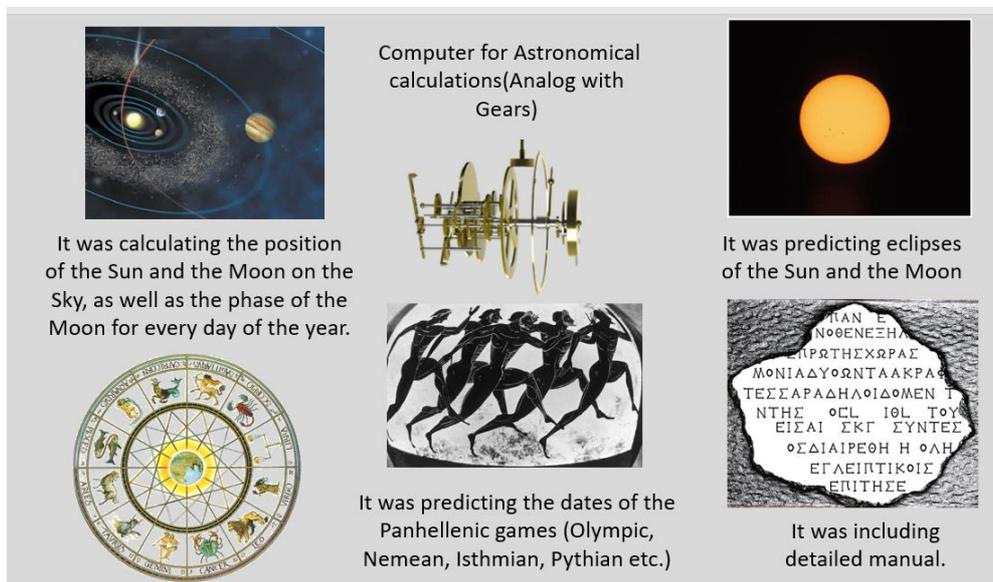


Figure 3. The use of the Antikythera Mechanism and the calculations it could perform.

But what exactly could the Antikythera mechanism calculate? The mechanism was used to calculate the exact position of the Sun, the Moon and possibly the planets in the sky. It calculated the phases of the Moon, predicted eclipses, and indicated the start date of the Pan-Hellenic games. It contained a manual with

detailed instructions (Fig. 3). (see, <https://www.antimech.com>).

It had front and back doors, with astronomical, geographical and technological inscriptions covering much of the exterior of the Mechanism. Not a single analogous ancient mechanism has been found so far.

In figure 4 a replica of the Antikythera Mechanism and the corresponding functional diagram of the gear trains is shown (Efstathiou et. al, 2021).

The operator, by turning the moon pointer, gives motion to all the gears that in turn rotate two pointers on the front, and 5 pointers on the back side.

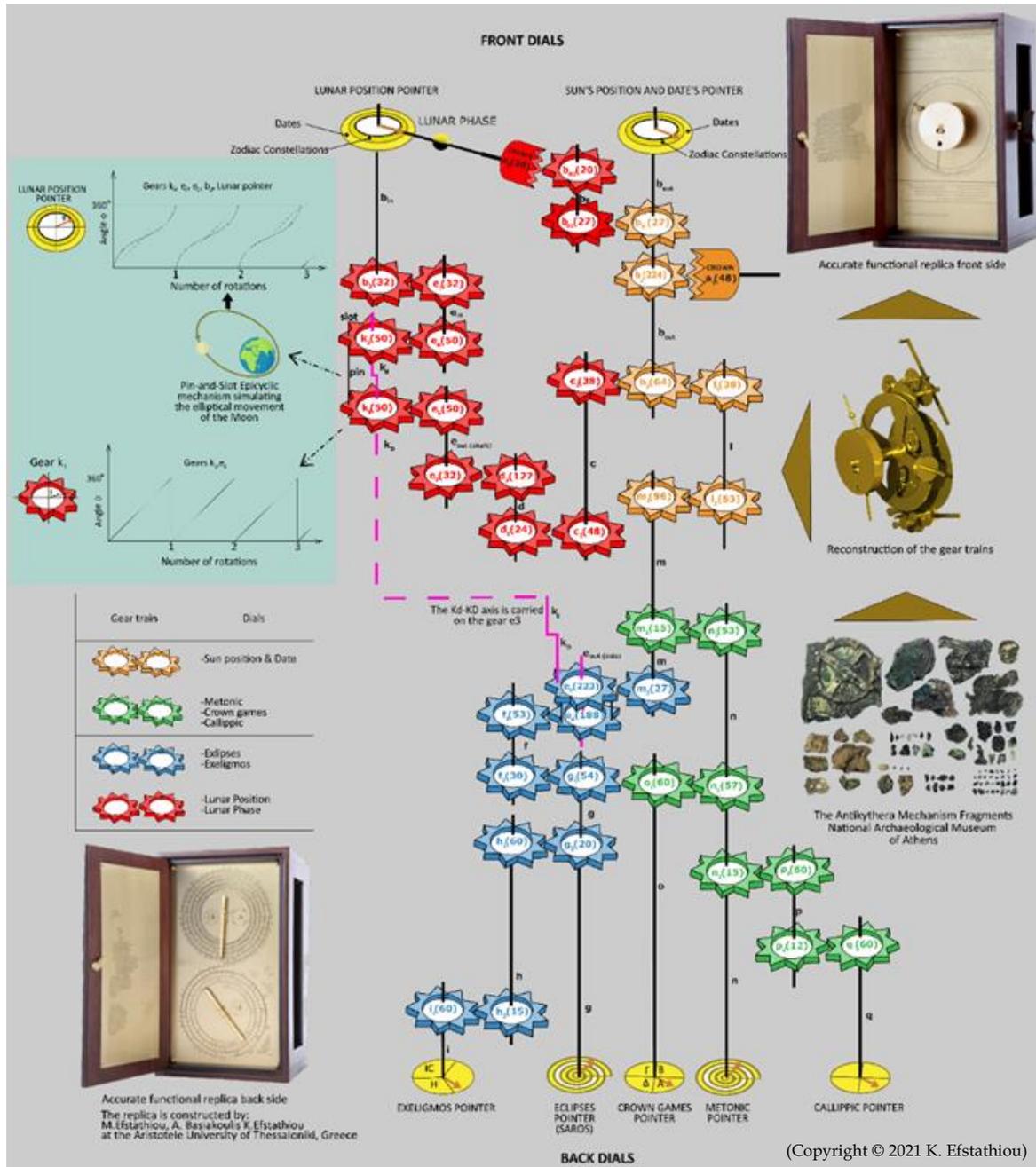


Figure 4. A functional diagram of the gear trains of the Antikythera Mechanism.

On the Mechanism's front side (Fig. 5 left), there were two concentric circular scales. The outer scale had 365 subdivisions representing days of the year. The inner scale had 360 subdivisions and the names of the 12 zodiac constellations. On the back side of the mechanism (Fig. 5 right) two spiral scales were found. The upper spiral consists of 5 windings, with its total length divided in 235 sections, corresponding to the

235 months of the Metonic period. The Metonic period correlates the Solar (annual) to the Lunar calendar. It lasts 235 lunar months corresponding exactly to 19 years. On these sections the ancient names of the 12 Lunar months were carved and were repeated until all 235 months were completed. The lower back dial, is a Saros eclipse-prediction dial, arranged as a

four-turn spiral of 223 lunar months, with glyphs indicating eclipse predictions (see also: Voulgaris et al., 2021).

The small dial within the Metonic spiral displayed the celebration year of the ancient Panhellenic crown games (Freeth et al., 2008). The scale was proved to indicate the year of the ancient Greek crown games, with the years of the four-year Olympic cycle being

written internally in each quadrant, with the letter "L" symbolizing the year and the words OLYMPIA, PYTHIA, ISTHMIYA, NEMEA, NAA and HALIEIA written peripherally to the scale.

The operation of this scale for the Panhellenic Games was an unexpected finding, which gave the hitherto purely astronomical Mechanism a social character.

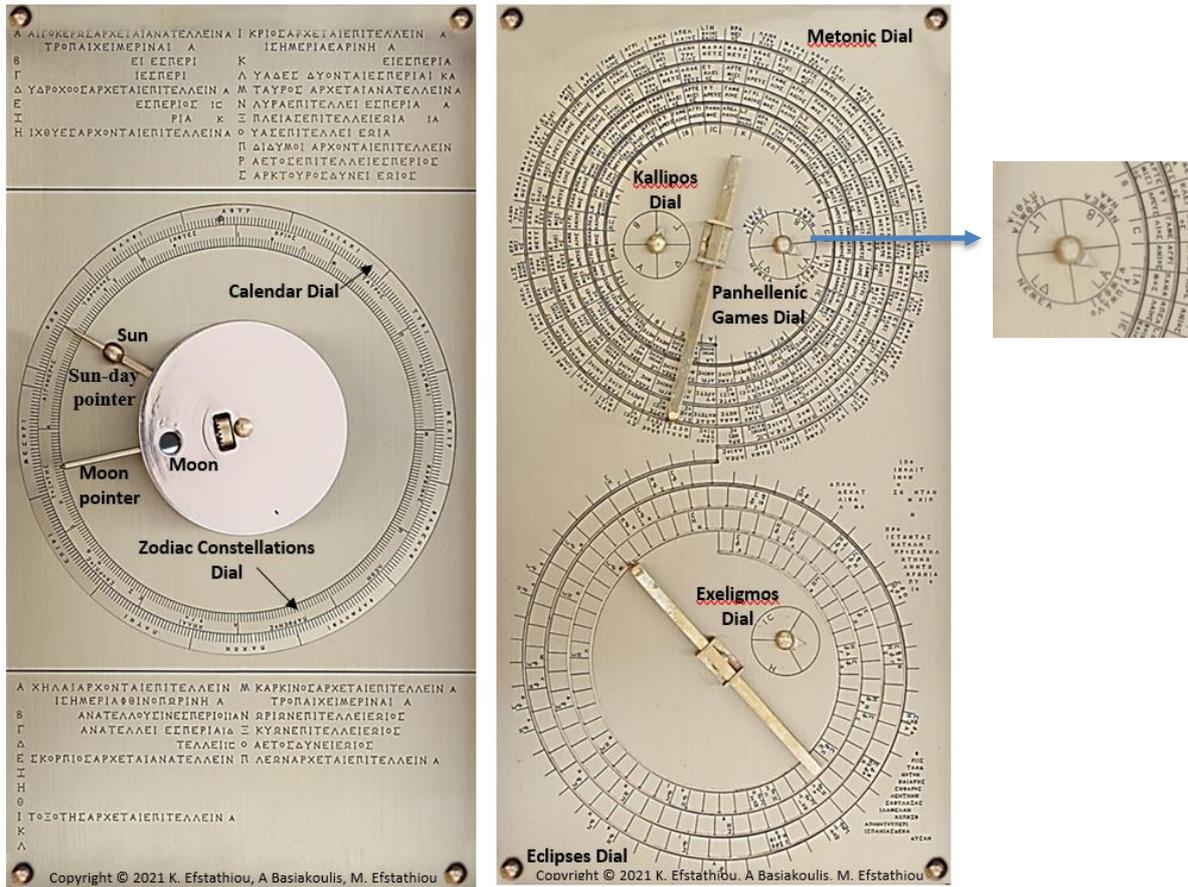


Figure 5. The front (left) and the back (right) dials of the Antikythera Mechanism

3. The Pythian Games

The Pythian Games were founded sometime in the 6th century BC. In legend, they were started by Apollo after he killed Python and set up the oracle at Delphi¹. After the end of the First Sacred War 595–585 BC, it was decided to fundamentally reorganize the Pythian, which were now carried out every four years; two years after the Olympic Games. The Pythian Games were ranked second in importance behind the Olympics. Unlike the Olympics, Pythian Games also featured competitions for art and dance, which pre-dated the athletic portion of the games, and

women were allowed to take part in some events. They were held at Apollo sanctuary at Delphi (Figs 6a and 6b).

As already mentioned, the two most important Pan-Hellenic Crown Games were the Olympics and the Pythian. Both Games were celebrated every four years. We know that the first celebration of the Olympic Games was held in Olympia in 776 BCE, and of the Pythian Games in Delphi in 582 BCE. The games continued to be held during the Hellenistic and the Roman period. However, it was Emperor Theodosius who finally decided that all worship practices, including the Games, should be stopped.

¹ Ovid, *The Metamorphoses*, 1.445-6; Pausanias. *Description of Greece* 6.14 Tran. by W.H.S. Jones and H.A. Ormerod, Cambridge, MA, Harvard University Press; London, William Heinemann Ltd. 1918; Pindar. *The Odes of Pindar* including the principal fragments with

an introduction and an English Translation by Sir John Sandys, Cambridge, MA., Harvard University Press; London, William Heinemann Ltd. 1937.



Figure 6a. The archaeological site of Delphi



Figure 6b. The stadium of Delphi, Greece, By Konstantinos Tamateas - Own work, CC BY-SA 4.0, <https://commons.wikimedia.org/w/index.php?curid=72873267>

The last Olympic Games were held in 393 AD, after a total of 293 events, lasting more than a millennium.

Considering that the Pythian were celebrated two years before or after the Olympics, their last event must have taken place after the 292nd Olympics, of 389

AD. This means that the last celebration of the Pythian took place in 391 AD.

Before the transition to the BC/AD dating system, ancient Greeks used a different system that was based on the count of the Olympiad plus the year(s) within its cycle, 1 to 4. One good example to understand the

relation between the two systems is the dating of the Battle of Marathon. Based on the BC/AD dating system the Battle of Marathon between Greeks and Persians took place on 490 BC. The Greek historian Herodotus mentions that the Battle took place during the 3rd year of the 72nd Olympiad. 71 Olympiads of 4 years each make $71 \times 4 = 284$ years. By adding the 3 years of the 72nd Olympiad we get 287 years. If we subtract them from the year before the 1st celebration of the Olympic games (776 BC) the result is $777 - 287 = 490$ BC.

The introduction of the Anno Domini (BC/AD) dating system in the 6th century AD, creates the false impression that Olympic Games were at some point held in 5 years' time after previous, instead of 4 years as normal. Specifically, based on the BC/AD system, the 195th Olympiad is considered to have taken place in 4 BC (-4) whereas the next Olympiad (196th) in 1 AD. It may be wrongly assumed that there is a five-year interval between the two Olympiads since $-4 + 5 = 1$. However, this is not the case because year 0 (zero) is omitted from the BC/AD dating system and as a result $-4 + 4 = 1$ and not $-4 + 4 = 0$. Thus, in the BC era we have the Olympic Games taking place in the years 776, 772, 768, ..., 12, 8, 4 BC (even years) and in the AD era the years 1, 5, 9, ..., 385, 389, 393 AD (odd years).

The timing of all major Hellenic Crown (Stephanites) Games was set by astronomical tradition. We know from written sources that the Olympic Games (as inscribed also on the back plate of the Antikythera Mechanism) began around a full Moon in "midsummer", suggesting the first or second month after the solstice (Seiradakis et. Al., 2018).

Literary and epigraphic sources (Hannah, 2012) indicate that the Pythian Games were celebrated in the third year of the Olympiad, on the seventh day of the month Boukatios, which was the second month after the summer solstice in the lunar calendar of Delphi. The Pythian lasted for about five days, with the first being on the 7th of the month of Boukatios.

The beginning of the lunar months was *NOYMH-NIA*, the new moon. In the calendars of the ancient Greek cities, as well as the Babylonian ones, the lunar month was defined from New Moon; to be exact, from the first day that the moon became visible immediately after the phase of the New Moon.

Considering that Boukatios was the second month after the summer solstice, it appears that Pythian must have begun 7 days after the first day, when the

2nd new moon following the summer solstice becomes visible.

The Summer solstice is the 21st of June.

The 1st new moon following the summer solstice appears between June 22 and July 21.

The 2nd new moon appears between July 22 and August 21.

The 1st day that the 2nd new moon following the summer solstice becomes visible is located between July 23 and August 22.

The 7th day after the 2nd new moon following the summer solstice becomes visible is between July 29 and August 28.

Following the above rationale and calculations the Pythian games should be celebrated, depending on the year, between July 29 and August 28

As mentioned before, the last celebration of the Pythian took place in 391 AD. Considering it was celebrated every 4 years, then the next Pythian, had they continued uninterrupted, must be celebrated in the year 2023, 7 days after the first day, when the 2nd new moon following the summer solstice becomes visible.

In Fig. 7 a new replica of the Antikythera Mechanism is shown (Efstathiou et. al, 2021). To verify the prediction accuracy of the Mechanism we have redesigned the dates and zodiac scales of the front side on the Mechanism to correspond to the present era.

Also, an application, which simulates the operation of the physical model, has been developed in a virtual reality environment for Windows operating system (Fig. 8). The application has been developed on Unity platform in 2D format. The dates and zodiac scales of the front side of the Mechanism are redesigned to correspond to the present. A peculiarity of the application as well as the corresponding physical model is related to the scale of the zodiac signs. Due to the passing of about 2200 years from the time of construction of the Mechanism, and due to the phenomenon of the precession of the equinoxes, the zodiac constellations have rotated by about 30 degrees. For this reason, the scale of the signs was redesigned to reflect the current reality. The phenomenon of the earth's transient movement (precession of the equinoxes,) was known in antiquity (Efstathiou et. al, 2021). The indicators on both sides of the Mechanism are presented in an image format and not as a numerical result. This application is also used to verify the accuracy of the predictions on the corresponding physical model. The timing of the Pythian Games in the present era can be accurately calculated with the help of this application.



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Figure 7. Replica of the Antikythera Mechanism with dates and zodiac scales of the front side redesigned to meet present era.

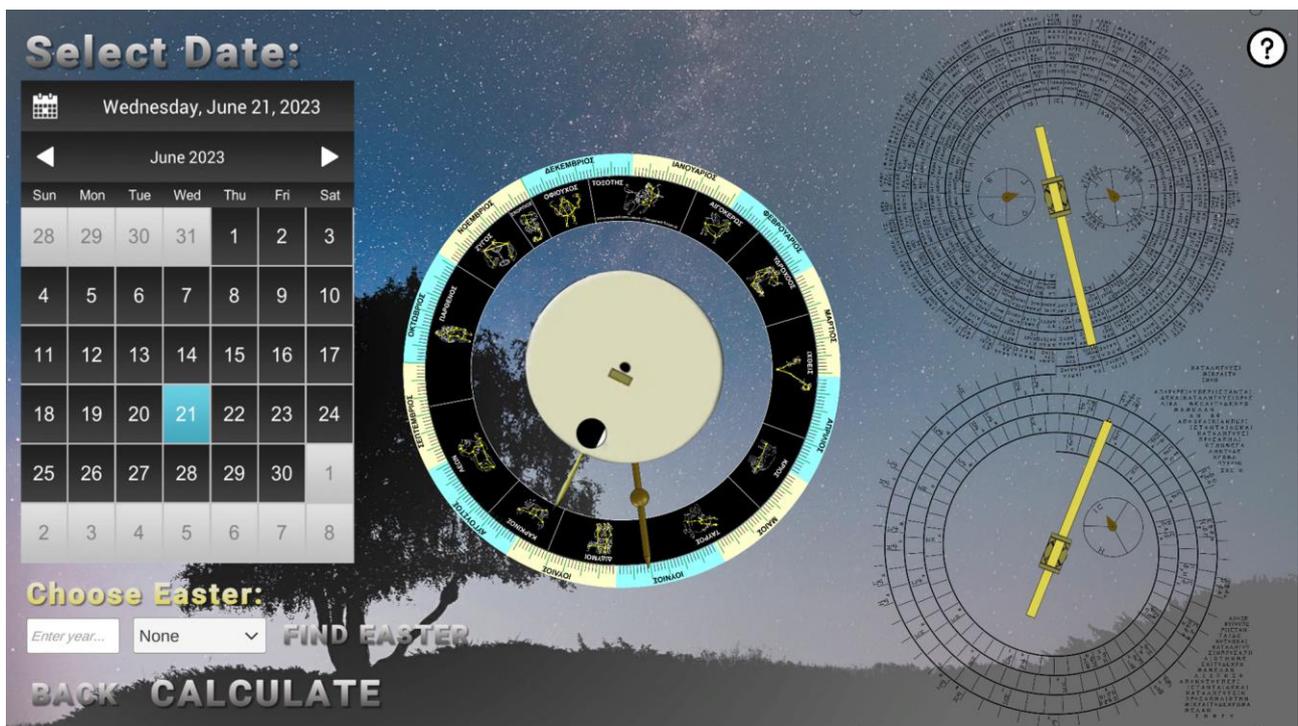


Figure 8. Application, simulating the operation of the Antikythera Mechanism replicas

As explained before the next Pythian Games, would be celebrated in the year 2023. In Fig. 9, the Moon phase at June 21 together with the summer solstice of 2023 is shown, as it has been calculated by the

Antikythera Mechanism Application. The moon is 4 days old (the last New Moon was on June 18, 2023).

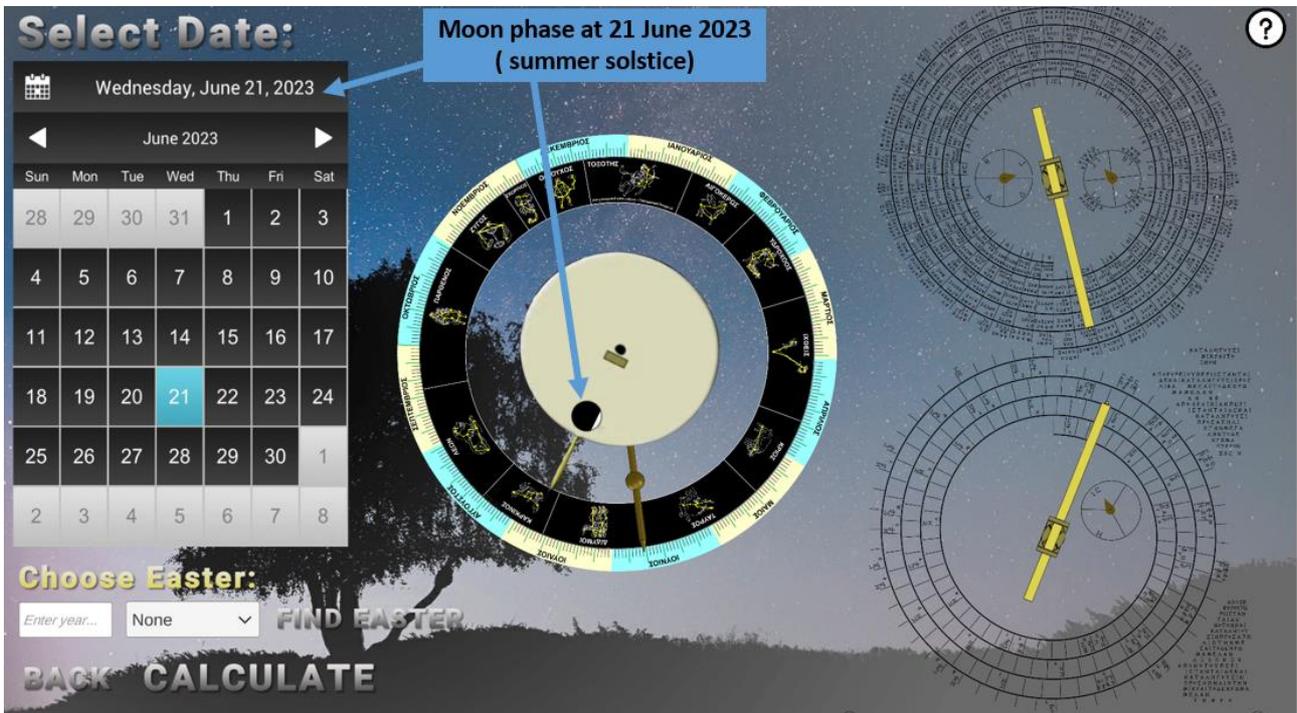


Figure 9. Astronomical phenomena for the 21 June (summer solstice) 2023

Fig. 10, illustrates when the 1st New Moon, following the summer solstice of 2023, will take place. This will happen on July 17.

The 2nd New Moon following the summer solstice 2023 will occur on August 16 (Fig. 11).

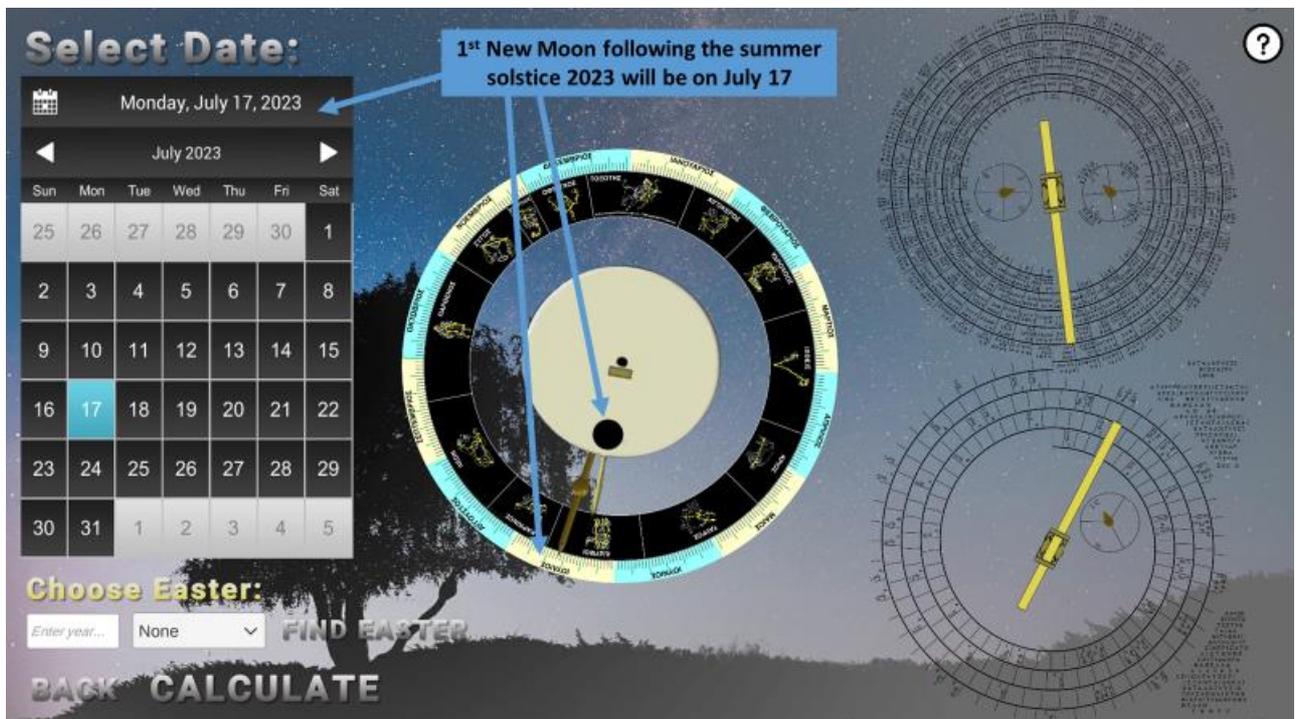


Figure 10. Astronomical phenomena for the 17th of July, 2023 (1st New Moon following the summer solstice)

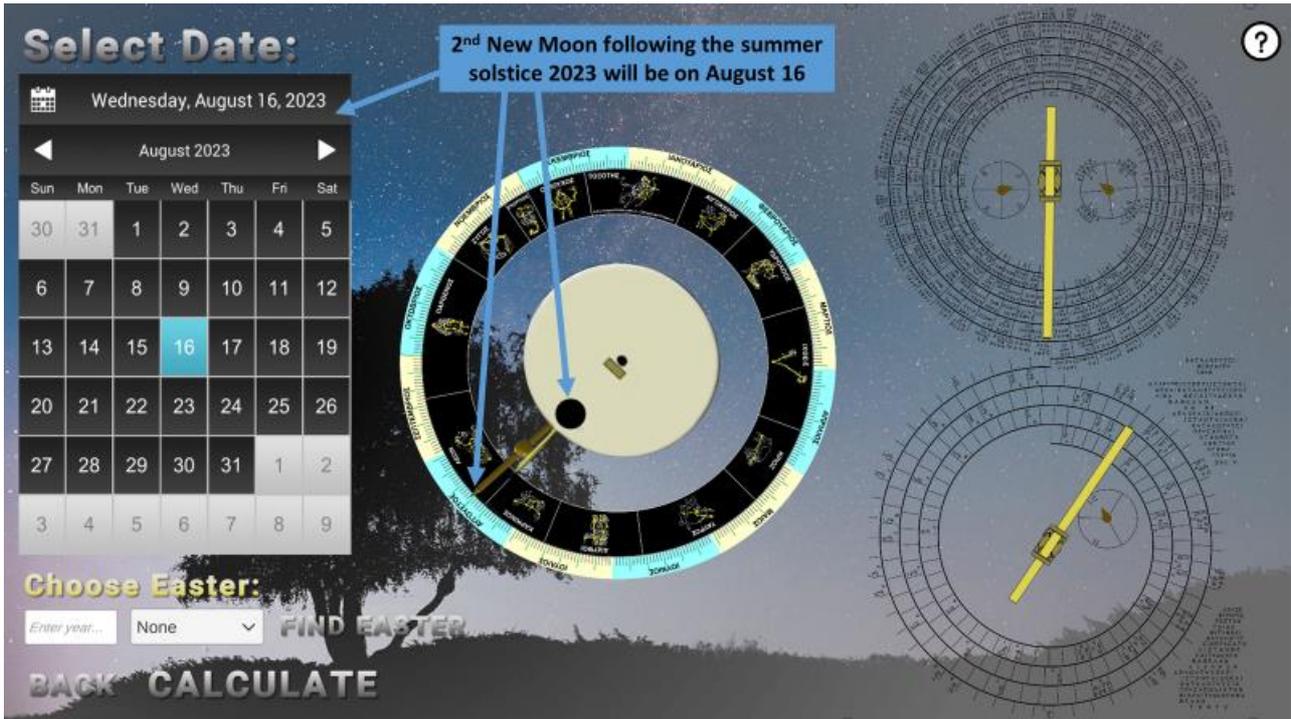


Figure 11. Astronomical phenomena for the 16th of August, 2023 (2nd New Moon following the summer solstice)

The 1st day that the 2nd new moon, after the summer solstice of the year 2023, will become visible is Friday August 18, 2023 (Figs. 12 and 13).



Moon phases 16, 17 and 18 August 2023



18 August 2023

Figure 12. Friday 18 August 2023, 1st day the new moon will become visible. Age of the moon 1,87 days, visible 4%, (https://www.calendar-12.com/moon_calendar/2023/august)

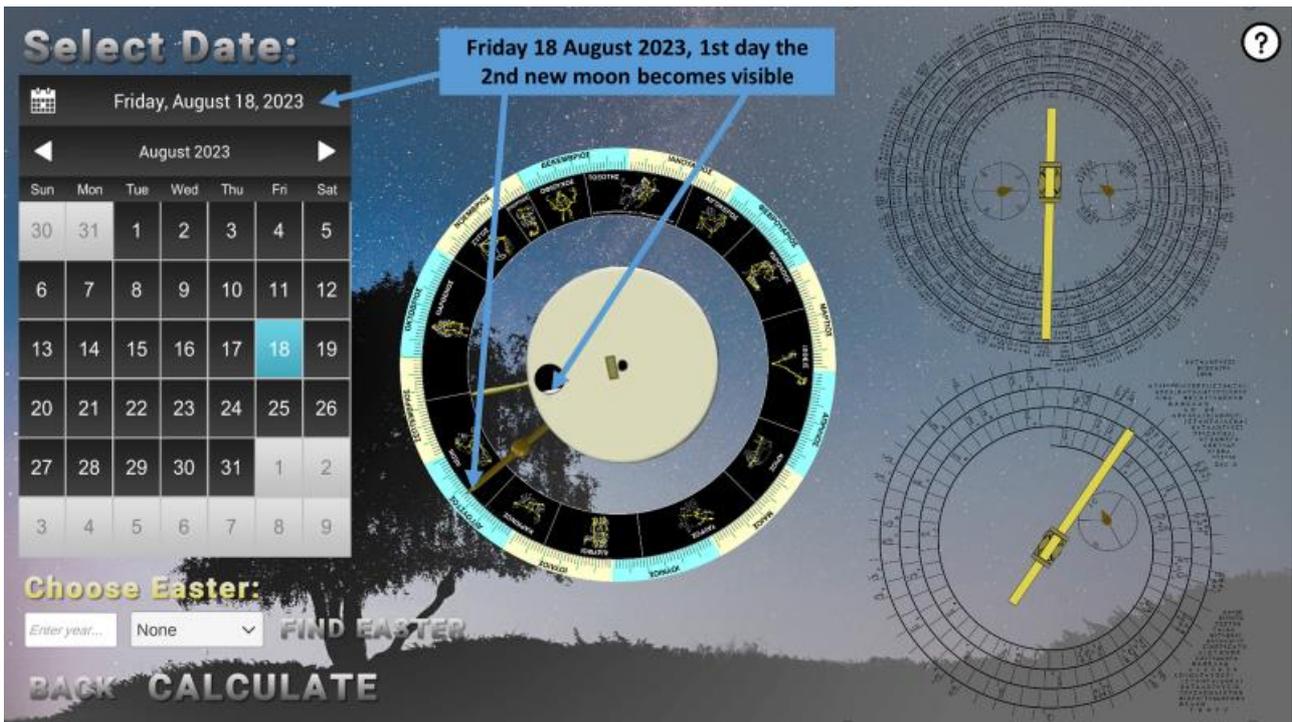


Figure 13. 1st day the 2nd new moon after the summer solstice of the year 2023, will become visible as it is calculated from the Antikythera Mechanism.

The 7th day after the 2nd new moon following the summer solstice, will become visible is Thursday August 24, 2023 (Fig. 14).

This is the day that the Pythian should be celebrated in 2023. The phase of the moon on this day is crescent.



Figure 14. The day that the Pythian should be celebrated in 2023 (Thursday August 24, 2023).

In the same way, the next Pythian after 2023 should be celebrated in the year 2027 on Tuesday, August 10

((Fig. 14). Again, the phase of the moon on this day is crescent.



Figure 15 The day that the Pythian should be celebrated in 2027 (Tuesday August 10, 2027).

The accuracy and precision of the astronomical calculations performed with the help of the Antikythera Mechanism presented in Figs 9-11 and 13-15 were confirmed by comparison to the corresponding outputs on the official NASA website (NASA SCYCAL Sky Events Calendar <https://eclipse.gsfc.nasa.gov/SKYCAL/SKYCAL.html?cal=2021#skycal>).

4. CONCLUSIONS

The preparations for the Pythian games began six months in advance. Nine citizens of Delphi, the Θεωποῖ, visited the Greek cities to announce the start of the games, inviting athletes, and to proclaim the Hieromina (*IEPOMHNI*), the period of the Holy Truce that would last three months.

Considering that each Greek city had its own calendar, but also the difficulty to keep track of days of

the year, if Delphi asked the rest of the Greeks to go to Delphi in the month of Boukatios on the seventh day, when the games would start, the remaining cities would have not been able to identify this day.

For this reason, they identified this day using astronomical phenomena, that would naturally occur everywhere on the same day.

As it turned out from the calculations with the help of the Antikythera Mechanism, the fact that the start of the games always took place in a crescent phase of the moon, was also important, because this indicates that the games were held every year in the same astronomical phase, which for the people of that era was also the same time phase.

Considering information from written sources and using the Antikythera Mechanism we calculated that the next celebration of the Pythian Games, had they continued to be celebrated until today is Thursday 24 August 2023.

AUTHOR CONTRIBUTIONS

Conceptualization: K.E.; M.E; Methodology: K.E.; A.B., M.E.; Software: M.E., N.K.; Validation: A.B., M.E.; Formal analysis: M.E., A.B.; Investigation: K.E., M.E., A.B.; Resources: M.E., K.E.; writing – original draft preparation: K.E.; Writing – review and editing: K.E.; Visualization: A.B., M.E.; Supervision: K.E.; Project administration: K.E.; Funding acquisition: not applicable. All authors have read and agreed to the published version of the manuscript.

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