

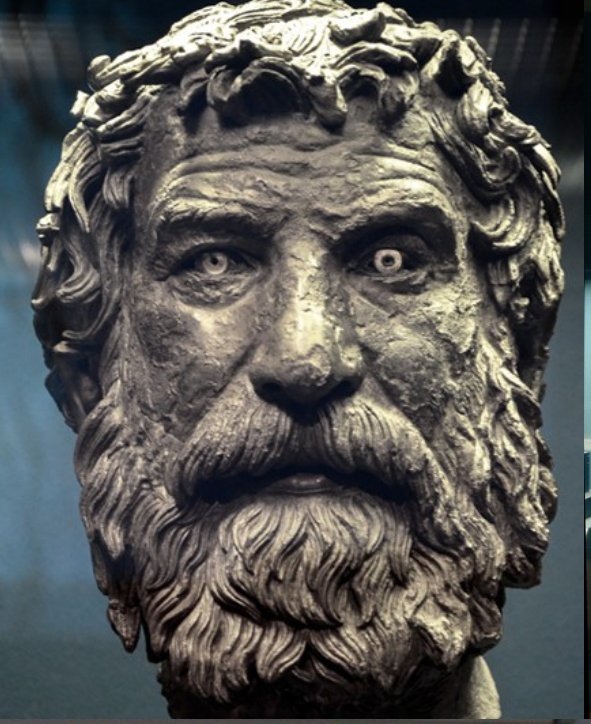
Die Mondmaschine

Prof. em. Thomas Weibel • www.thomasweibel.ch • thomas.weibel@bluewin.ch


INDIANA JONES
























BBC

Marcus Tullius Cicero: De natura deorum (45/44 v. Chr.)

«Quodsi in Scythiam aut in Britanniam sphaeram aliquis tulerit hanc quam nuper familiaris noster effecit Posidonius, cuius singulae conversiones idem efficiunt in sole et in luna et in quinque stellis errantibus quod efficitur in caelo singulis diebus et noctibus.»

«Nehmen wir an, ein Reisender bringt ein Planetarium nach Skythien oder Britannien, wie es unser Freund Poseidonius konstruiert hat, dessen einzelne Umdrehungen an Sonne, dem Mond und den fünf Planeten dasselbe bewirken, was sich am wirklichen Himmel in Tagen und Nächten abspielt.»



Marcus Tullius Cicero: De re publica I (54-51 v. Chr.)

«Hoc autem sphaerae genus, in quo solis et lunae motus inessent et earum quinque stellarum quae errantes et quasi vagae nominarentur, in illa sphaera solida non potuisse finiri, atque in eo admirandum esse inventum Archimedi, quod excogitasset quem ad modum in dissimillimis motibus inaequabiles et varios cursus servaret una conversio.»

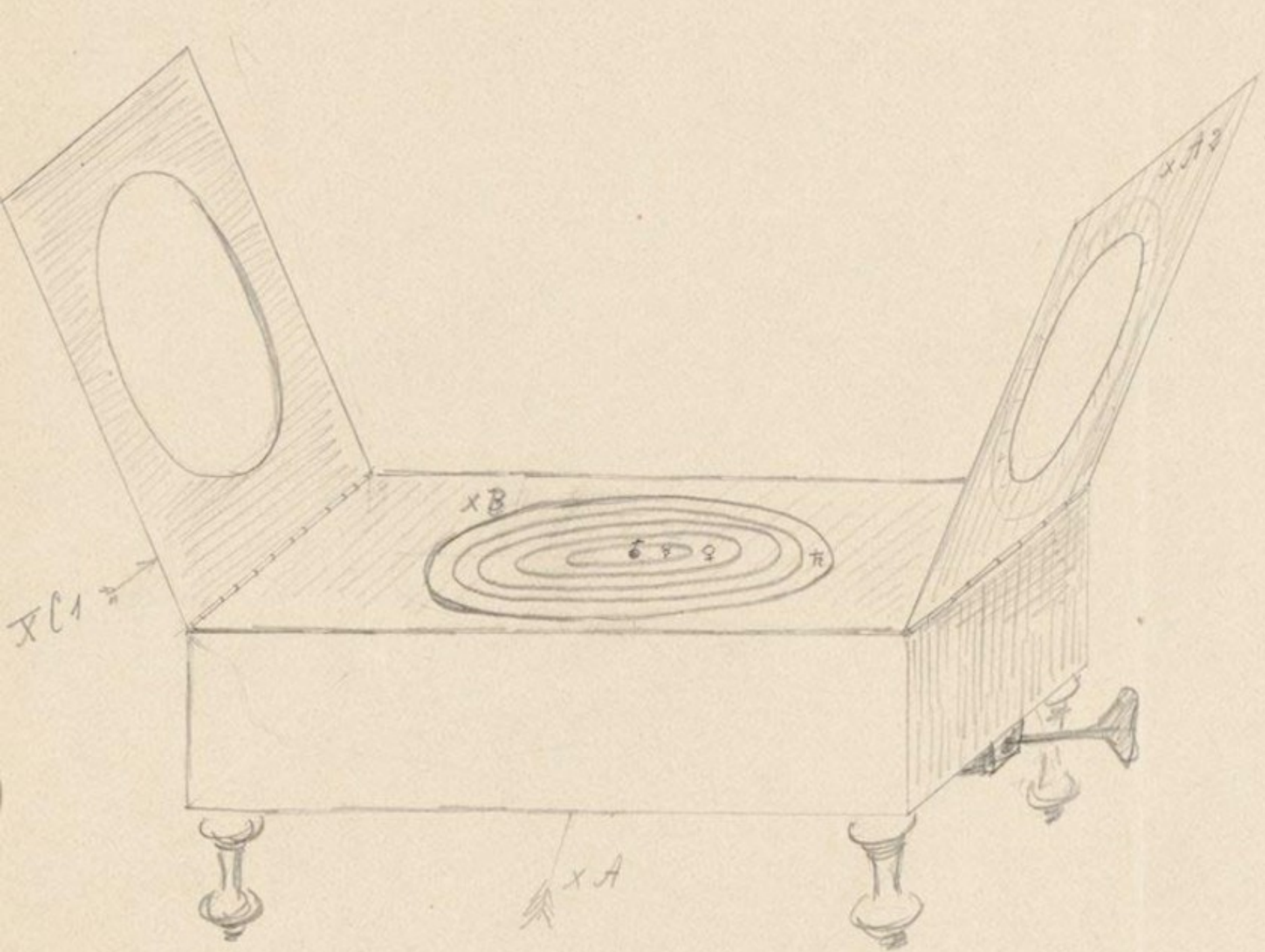
«Diese Art von Globus, auf dem die Bewegungen der Sonne und des Mondes und der fünf Planeten, die Wanderer genannt werden, umfasste mehr, als auf dem festen Globus gezeigt werden konnte. Die Erfindung des Archimedes verdiente besondere Bewunderung, weil er einen Weg gefunden hatte, durch eine einzige Drehung des Globus diese verschiedenen Bewegungen mit ihren unterschiedlichen Geschwindigkeiten darzustellen.»









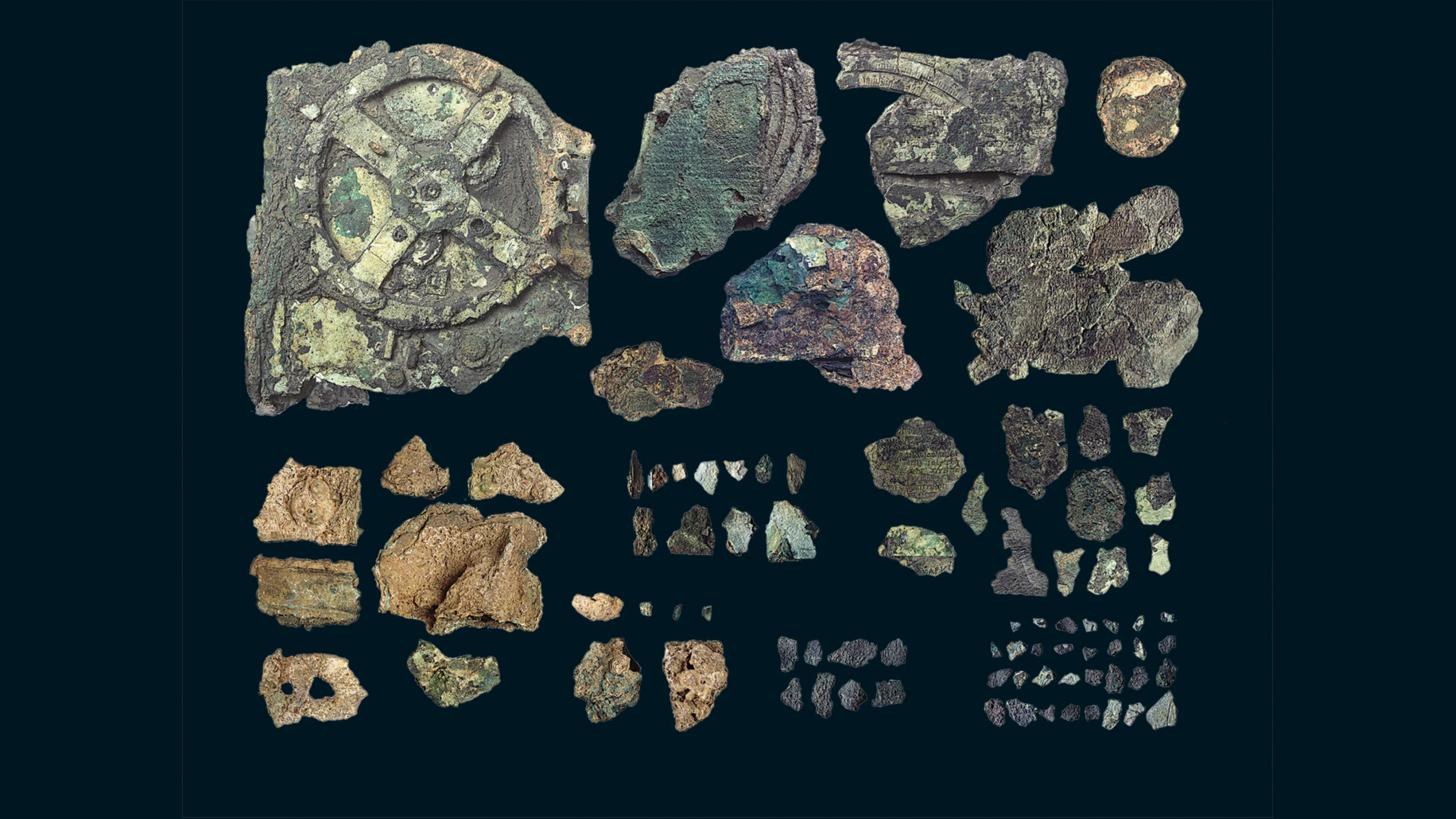

xB
xC1
xA











Our current knowledge of the **Antikythera Mechanism** [PDF] fsb.hr
JH Seiradakis, MG Edmunds - Nature Astronomy, 2018 - nature.com
... **Antikythera Mechanism** and an elementary geared Byzantine sundial 3 from around the late fifth or early sixth century bce. The **Antikythera Mechanism** ... 1), geared **mechanism**, made of ...
☆ Speichern 99 Zitieren Zitiert von: 45 Ähnliche Artikel Alle 5 Versionen Web of Science: 10 »

The **Antikythera mechanism** reconsidered [PDF] sagepub.com
MT Wright - Interdisciplinary science reviews, 2007 - journals.sagepub.com
... The considerable bulk of this '**Antikythera** treasure' included ... geared **mechanism**, was recognised only later. The first official description of what we now call the **Antikythera Mechanism** ...
☆ Speichern 99 Zitieren Zitiert von: 69 Ähnliche Artikel Alle 9 Versionen Web of Science: 21 »

Decoding the ancient Greek astronomical calculator known as the **Antikythera Mechanism** [PDF] shiftleft.com
T Freeth, Y Bitsakis, X Moussas, JH Seiradakis... - Nature, 2006 - nature.com
... The **Antikythera Mechanism** is a unique Greek geared device, ... shipwreck, the **Antikythera Mechanism** is technically more ... The **mechanism** predicted lunar and solar eclipses on the ...
☆ Speichern 99 Zitieren Zitiert von: 496 Ähnliche Artikel Alle 28 Versionen Web of Science: 175 »

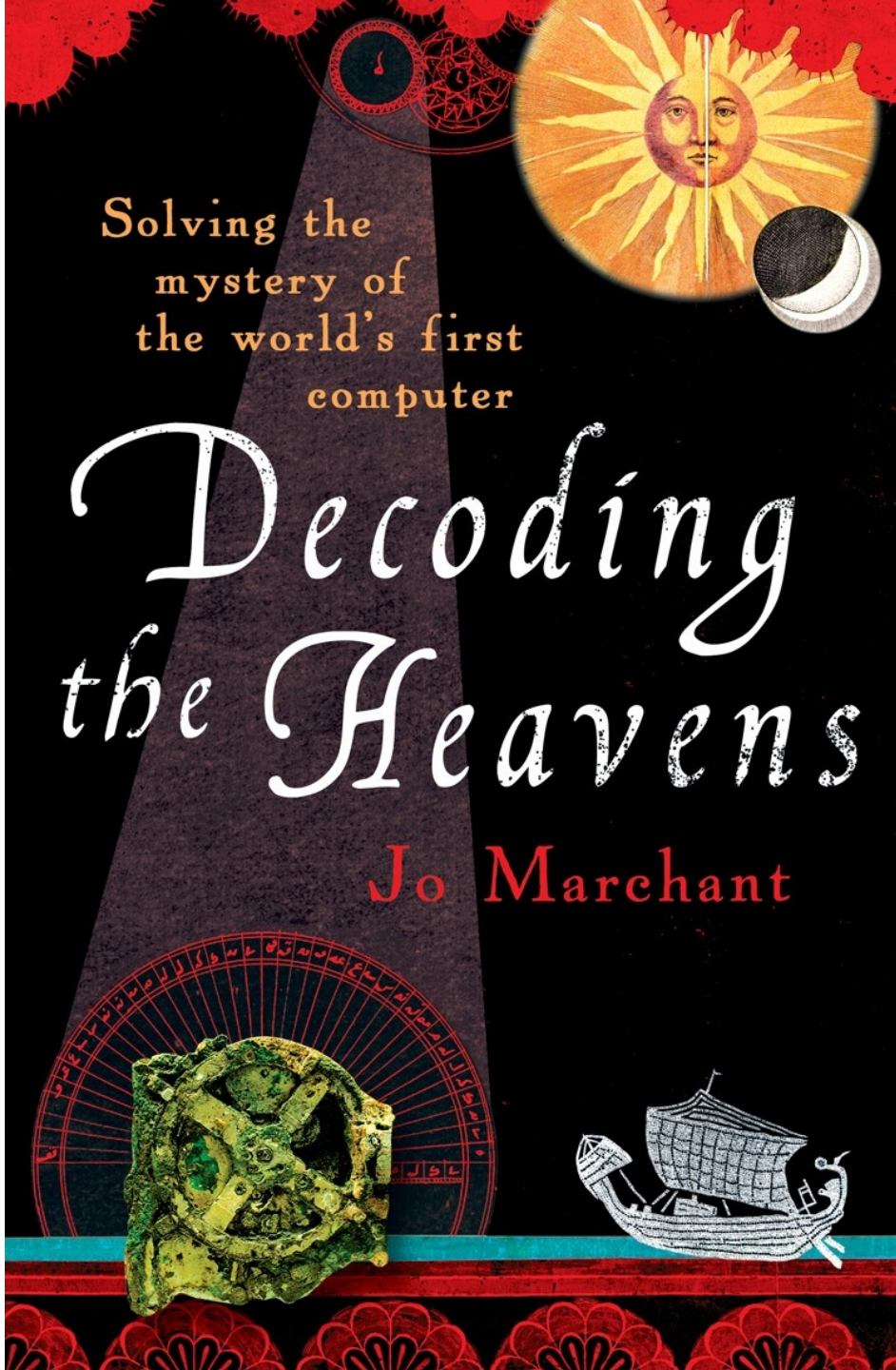
Gears from the Greeks. The **Antikythera mechanism**: a calendar computer from ca. 80 BC [PDF] jstor.org
D de Solla Price - Transactions of the American Philosophical Society, 1974 - JSTOR
... to appreciate the deep significance of the **Antikythera mechanism** which was known to me ... , I published a new evaluation of the **Antikythera mechanism** in an article, "Clockwork before ...
☆ Speichern 99 Zitieren Zitiert von: 363 Ähnliche Artikel Alle 7 Versionen Web of Science: 52 »

A Model of the Cosmos in the ancient Greek **Antikythera Mechanism** [PDF] nature.com
T Freeth, D Higgon, A Dacanalis, L MacDonald... - Scientific reports, 2021 - nature.com
... Here we propose that the **Antikythera Mechanism** itself calculated these synodic intervals by counting days on the Calendar Dial between synodic events indicated by the synodic scale ...
☆ Speichern 99 Zitieren Zitiert von: 58 Ähnliche Artikel Alle 21 Versionen Web of Science: 1 »

The **Antikythera mechanism** and the mechanical universe [PDF] tandfonline.com Full View
MG Edmunds - Contemporary physics, 2014 - Taylor & Francis
... based around the **Antikythera Mechanism**, an artefact from ... BC as witnessed by the **Antikythera Mechanism** comes as a great ... and functions of the **Antikythera Mechanism** are described. ...
☆ Speichern 99 Zitieren Zitiert von: 22 Ähnliche Artikel Alle 6 Versionen Web of Science: 9 »

[PDF] The **Antikythera mechanism**: a new gearing scheme [PDF] online.fr
MT Wright - Bulletin of the Scientific Instrument Society, 2005 - fsoso.online.fr
The **Antikythera Mechanism**, the oldest geared instrument in the world, became widely known through the work of Professor Derek de Solla Price; and for anyone seriously interested in ...
☆ Speichern 99 Zitieren Zitiert von: 61 Ähnliche Artikel Alle 4 Versionen »

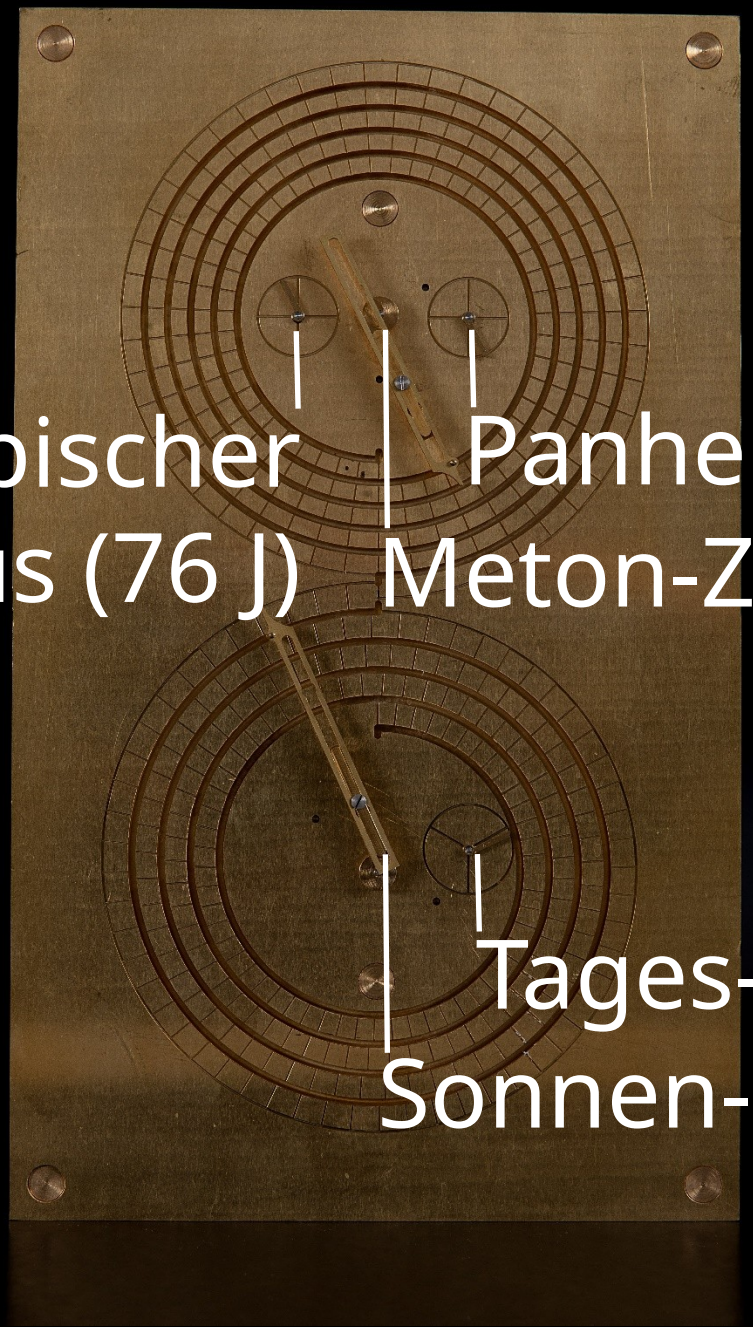
[PDF] Understanding the **Antikythera mechanism** [PDF] free.fr
MT Wright - ... Second International Conference on Ancient Greek ..., 2006 - hist.science.free.fr
... The fragmentary **Antikythera Mechanism**, recovered from a shipwreck that is dateable ... **Mechanism** remained but poorly understood. A new reconstruction of the **Antikythera Mechanism** ...
☆ Speichern 99 Zitieren Zitiert von: 24 Ähnliche Artikel Alle 2 Versionen »








Siderischer Zyklus
Sonnenjahr
Synodischer Zyklus (Mondphase)

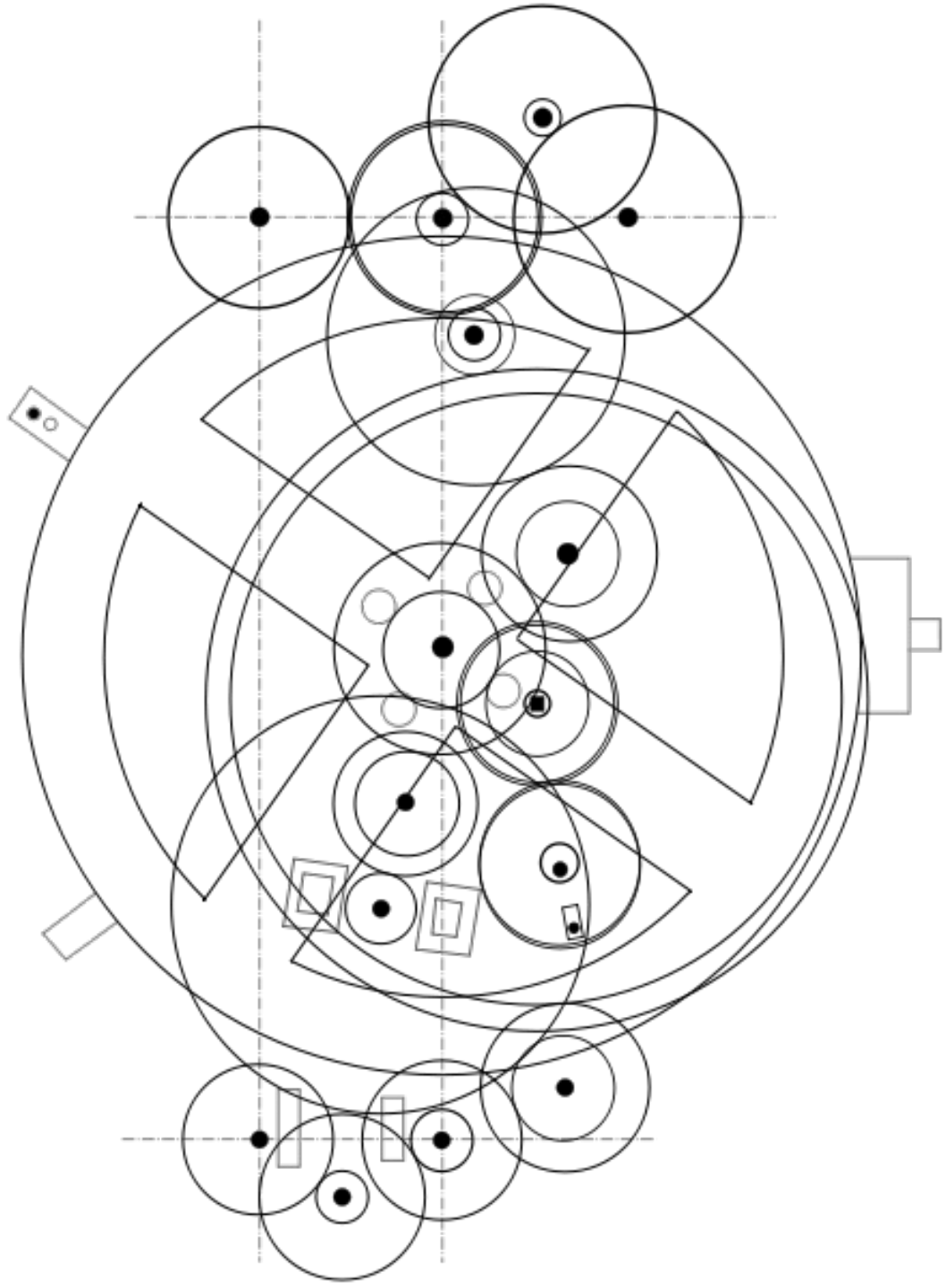


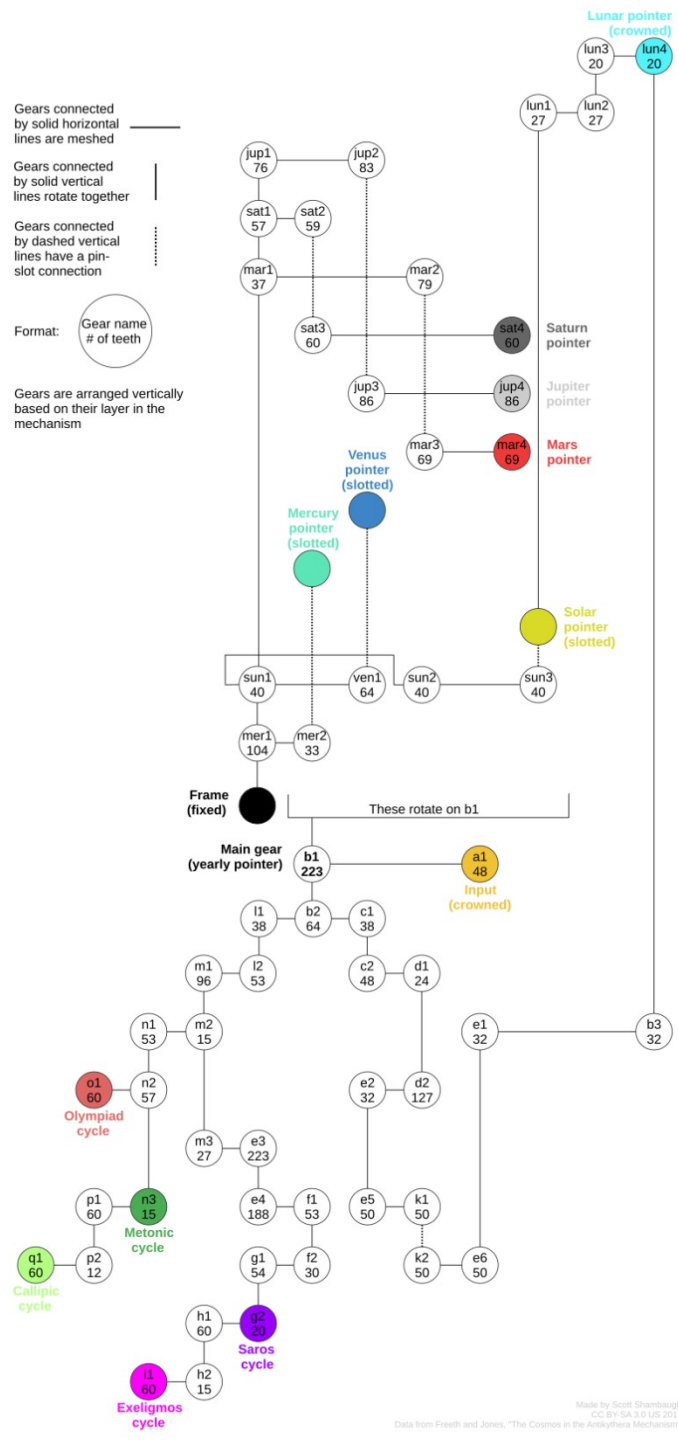
Kallippischer Zyklus (76 J)

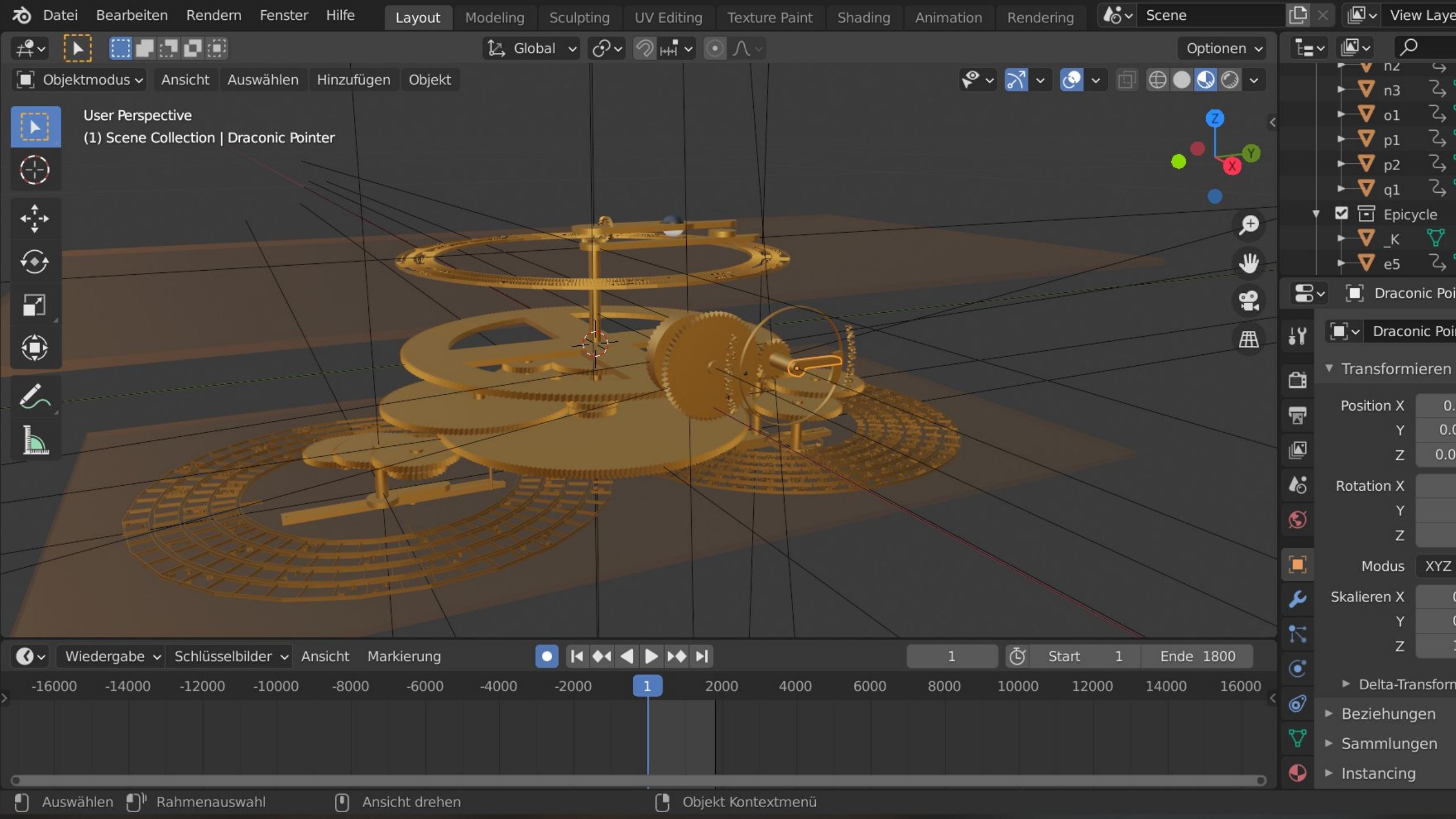
Panhellenische Spiele Meton-Zyklus (19 J)

Tages-/Nachtzeit Sonnen- und Mondfinsternisse

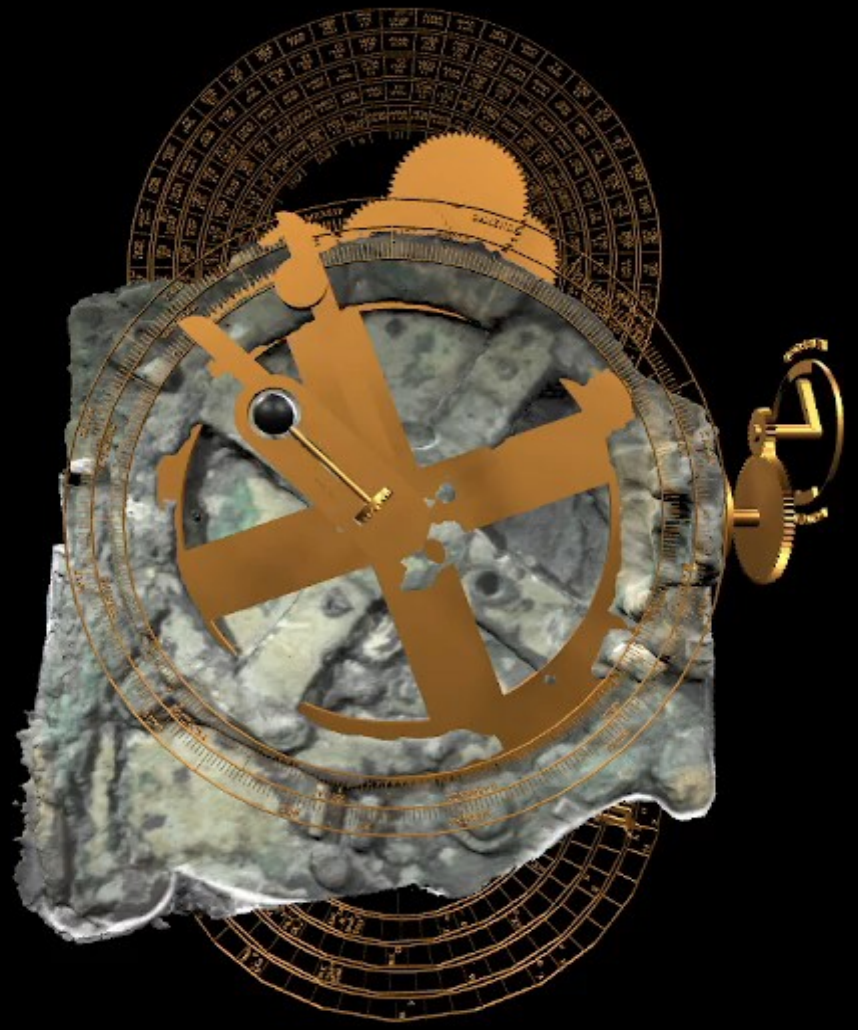





Gears connected by solid horizontal lines are meshed
Gears connected by solid vertical lines rotate together
Gears connected by dashed vertical lines have a pin-slot connection
Format:
Gear name
of teeth
Gears are arranged vertically based on their layer in the mechanism
Lunar pointer (crowned)
lun3 20
lun4 20
lun1 27
lun2 27
jup1 76
jup2 83
sat1 57
sat2 59
mar1 37
mar2 79
sat3 60
sat4 60
Saturn pointer
jup3 86
jup4 86
Jupiter pointer
mar3 69
mar4 69
Mars pointer
Venus pointer (slotted)
Mercury pointer (slotted)
Solar pointer (slotted)
sun1 40
ven1 64
sun2 40
sun3 40
mer1 104
mer2 33
Frame (fixed)
These rotate on b1
Main gear (yearly pointer)
b1 223
a1 48
Input (crowned)
l1 38
b2 64
c1 38
m1 96
l2 53
c2 48
d1 24
n1 53
m2 15
e1 32
b3 32
o1 60
n2 57
Olympiad cycle
e2 32
d2 127
m3 27
e3 223
p1 60
n3 15
Metonic cycle
e4 188
f1 53
e5 50
k1 50
q1 60
p2 12
Callipic cycle
g1 54
f2 30
k2 50
e6 50
h1 60
g2 20
Saros cycle
i1 60
h2 15
Exeligmos cycle
Made by Scott Shambaugh
CC BY-SA 3.0 US 2014
Data from Freeth and Jones, "The Cosmos in the Antikythera Mechanism"


Datei
Bearbeiten
Rendern
Fenster
Hilfe
Layout
Modeling
Sculpting
UV Editing
Texture Paint
Shading
Animation
Rendering
Scene
View Laye
Global
Optionen
Objektmodus
Ansicht
Auswählen
Hinzufügen
Objekt
User Perspective
(1) Scene Collection | Draconic Pointer
n3
o1
p1
p2
q1
Epicycle
_K
e5
Draconic Poi
Transformieren
Position X
Y
Z
Rotation X
Modus
XYZ
Skalieren X
Beziehungen
Sammlungen
Instancing
Wiedergabe
Schlüsselbilder
Ansicht
Markierung
1
Start 1
Ende 1800
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
2000
4000
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Auswählen
Rahmenauswahl
Ansicht drehen
Objekt Kontextmenü

the antikythera mechanism

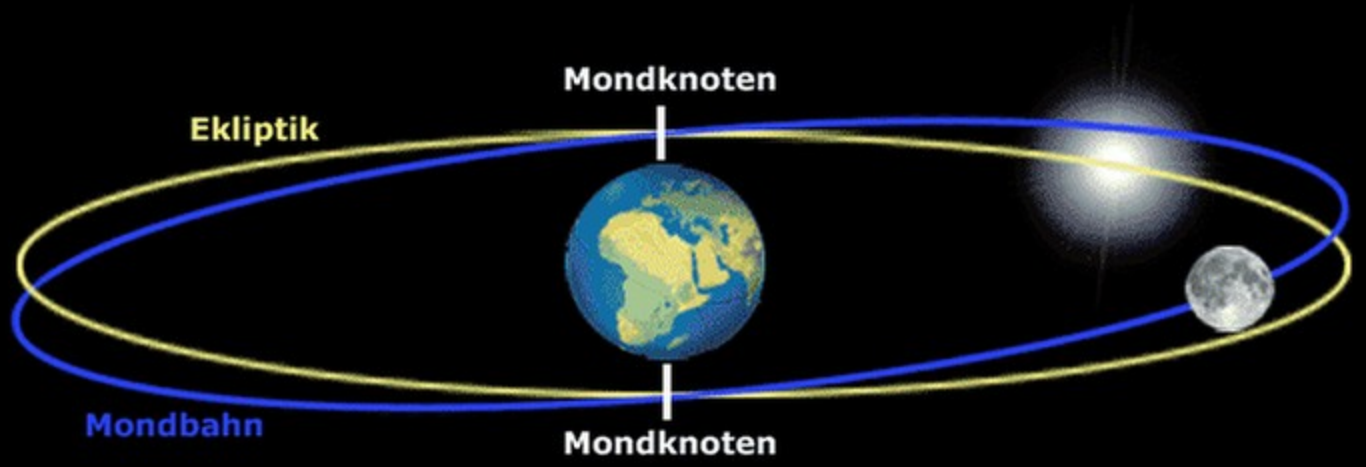


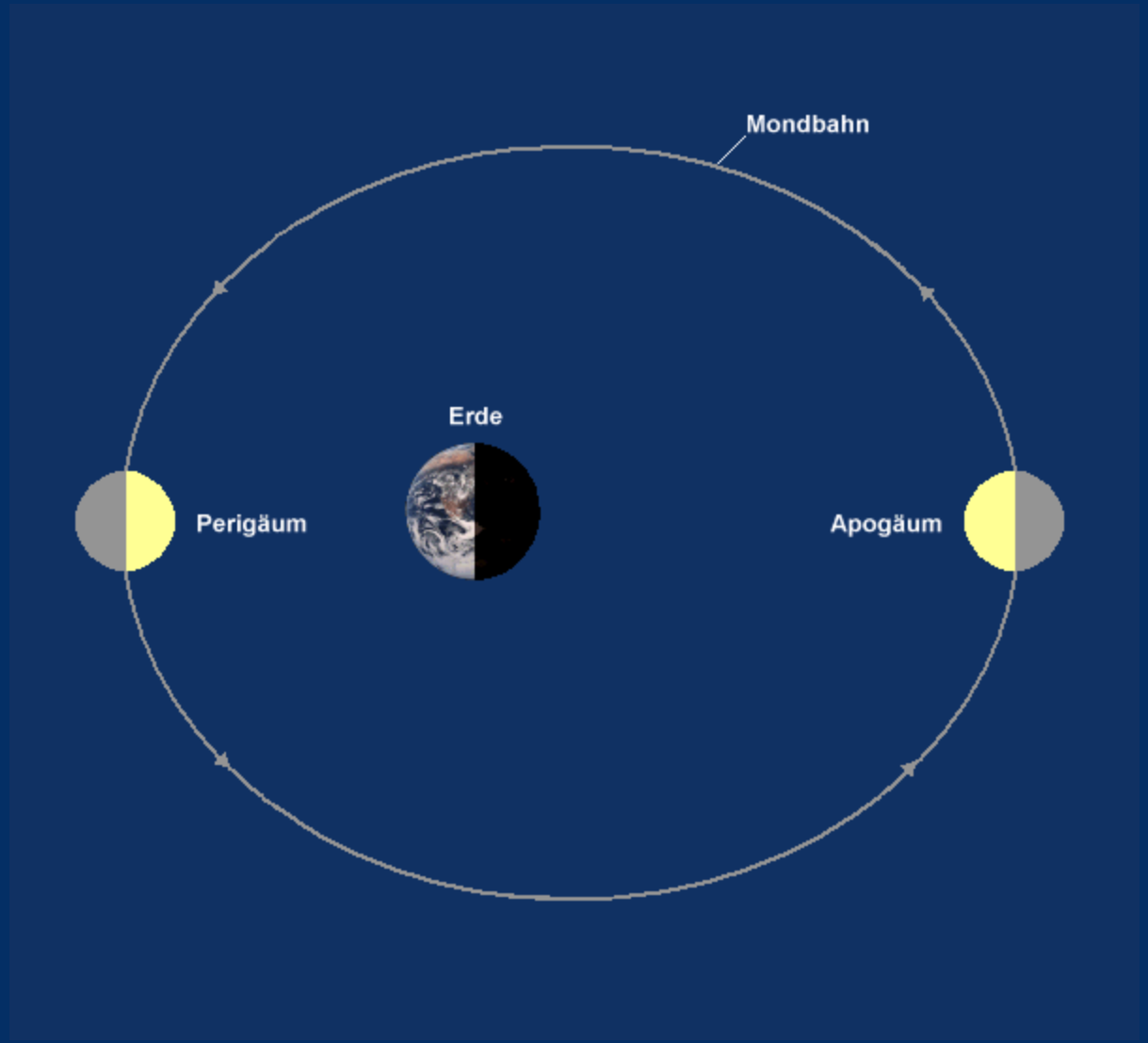
the
antikythera
mechanism



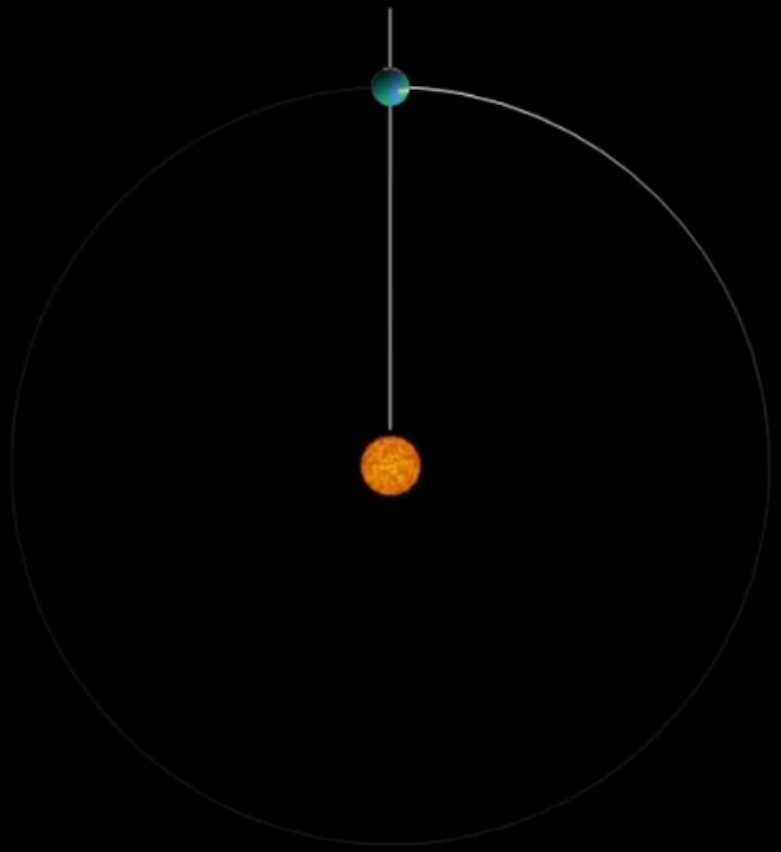
thomasweibel.ch/antikythera



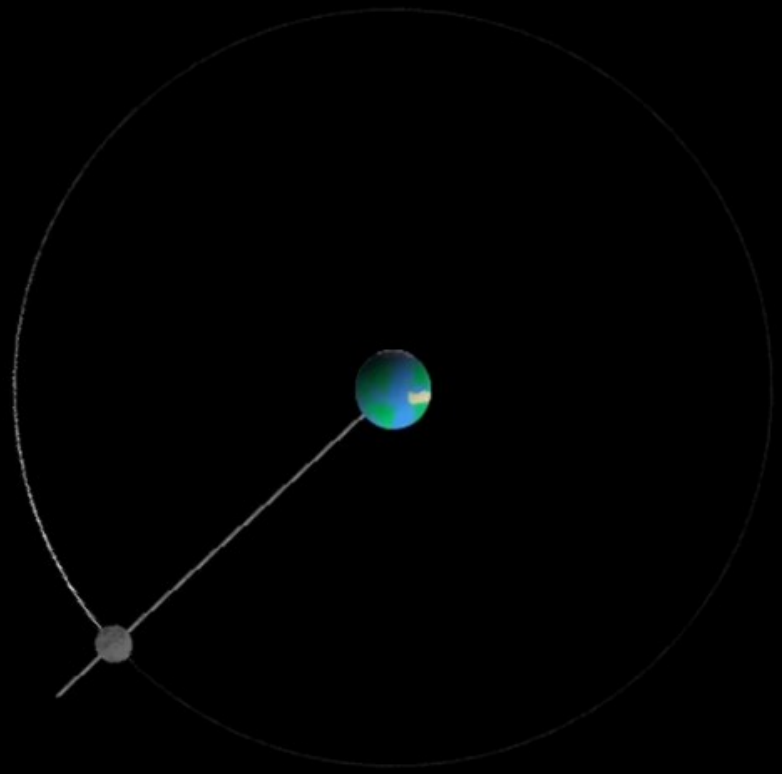

Mondknoten
Ekliptik
Mondbahn
Mondknoten


Mondbahn
Erde
Perigäum
Apogäum

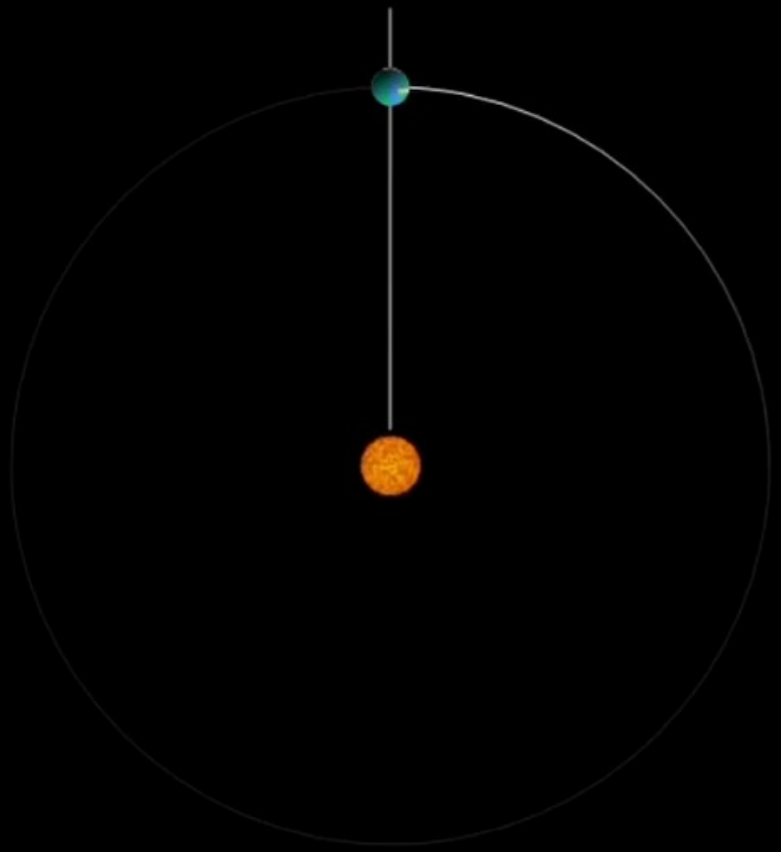




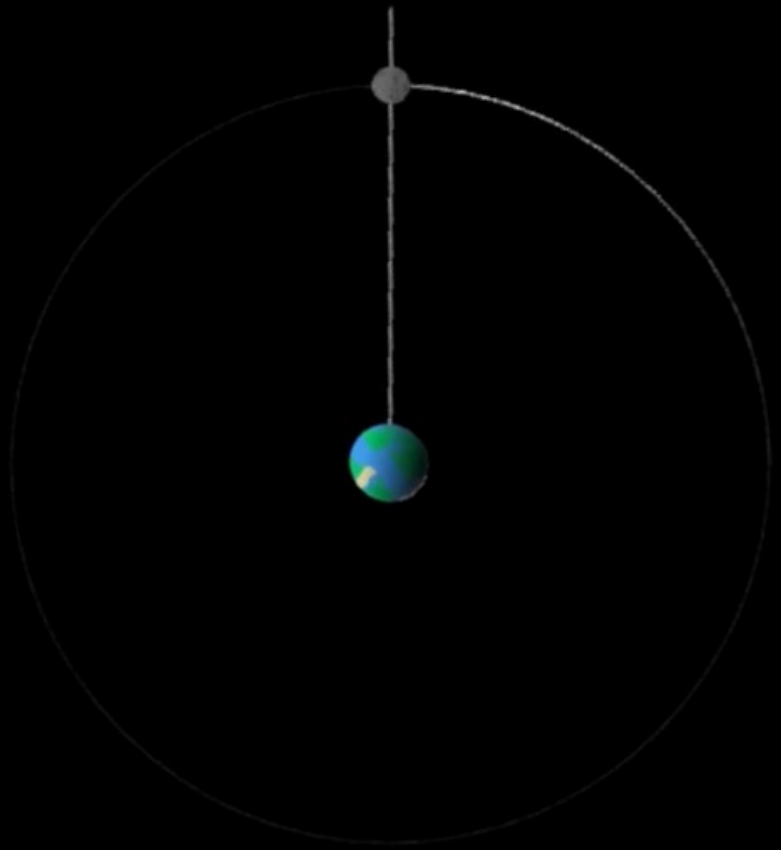
Sonne, Erde:
1 Jahr (tropisch)



Erde, Mond:
~12,37 Mondmonate (synodisch)



Sonne, Erde:
19 Jahre (tropisch)



Erde, Mond:
234,997 Mondmonate (synodisch)
235 Mondmonate (~-2h)



Vollmond,
5. Dezember 2006

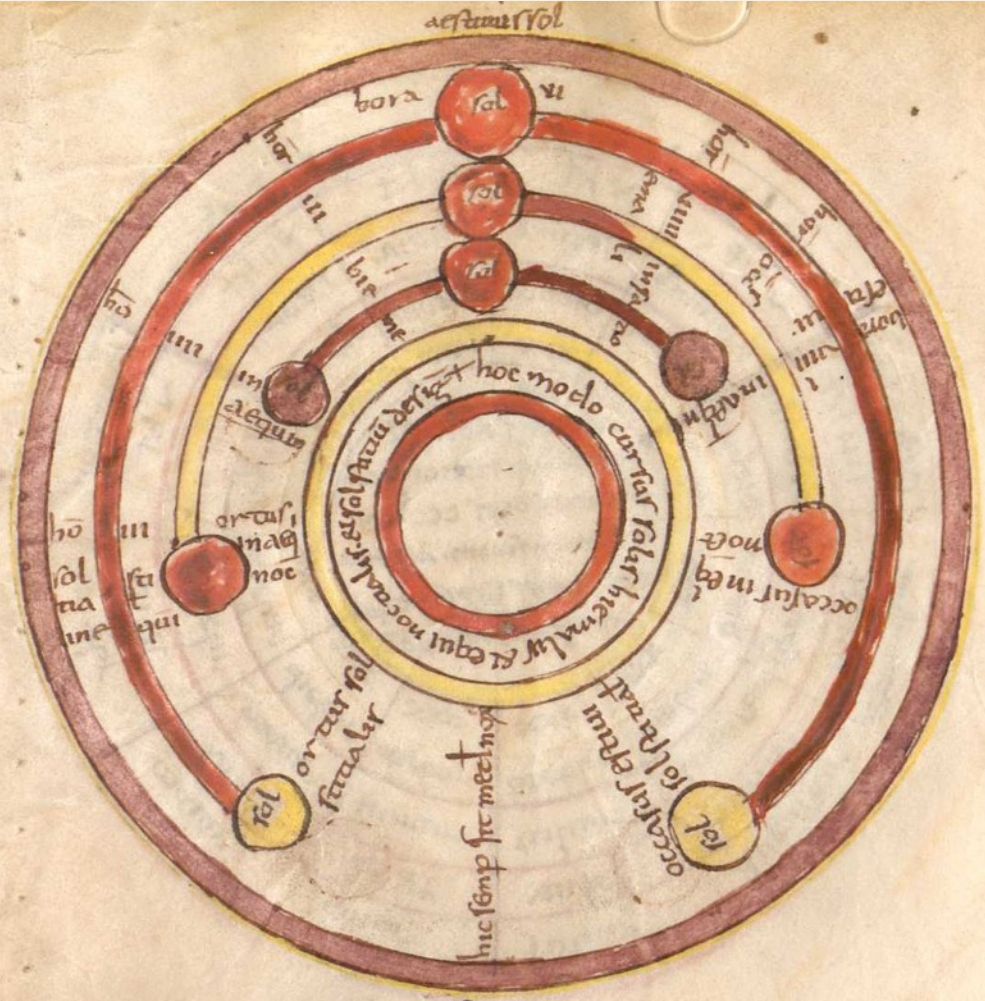
19 Jahre

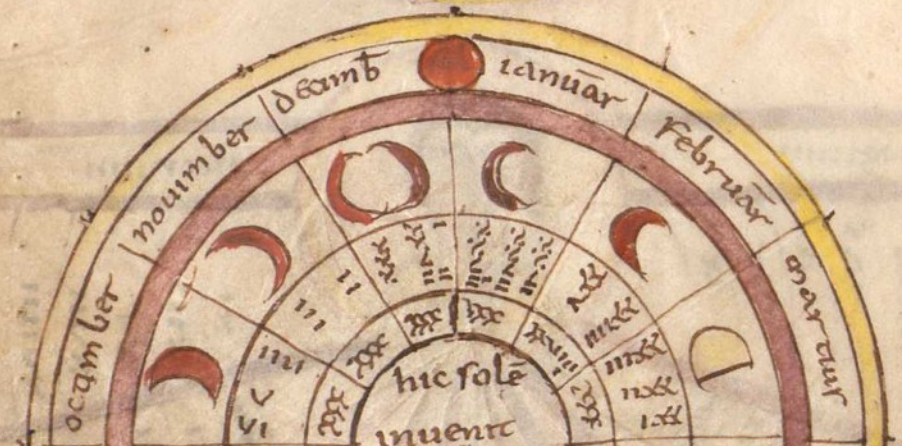
Vollmond
5. Dezember 2025

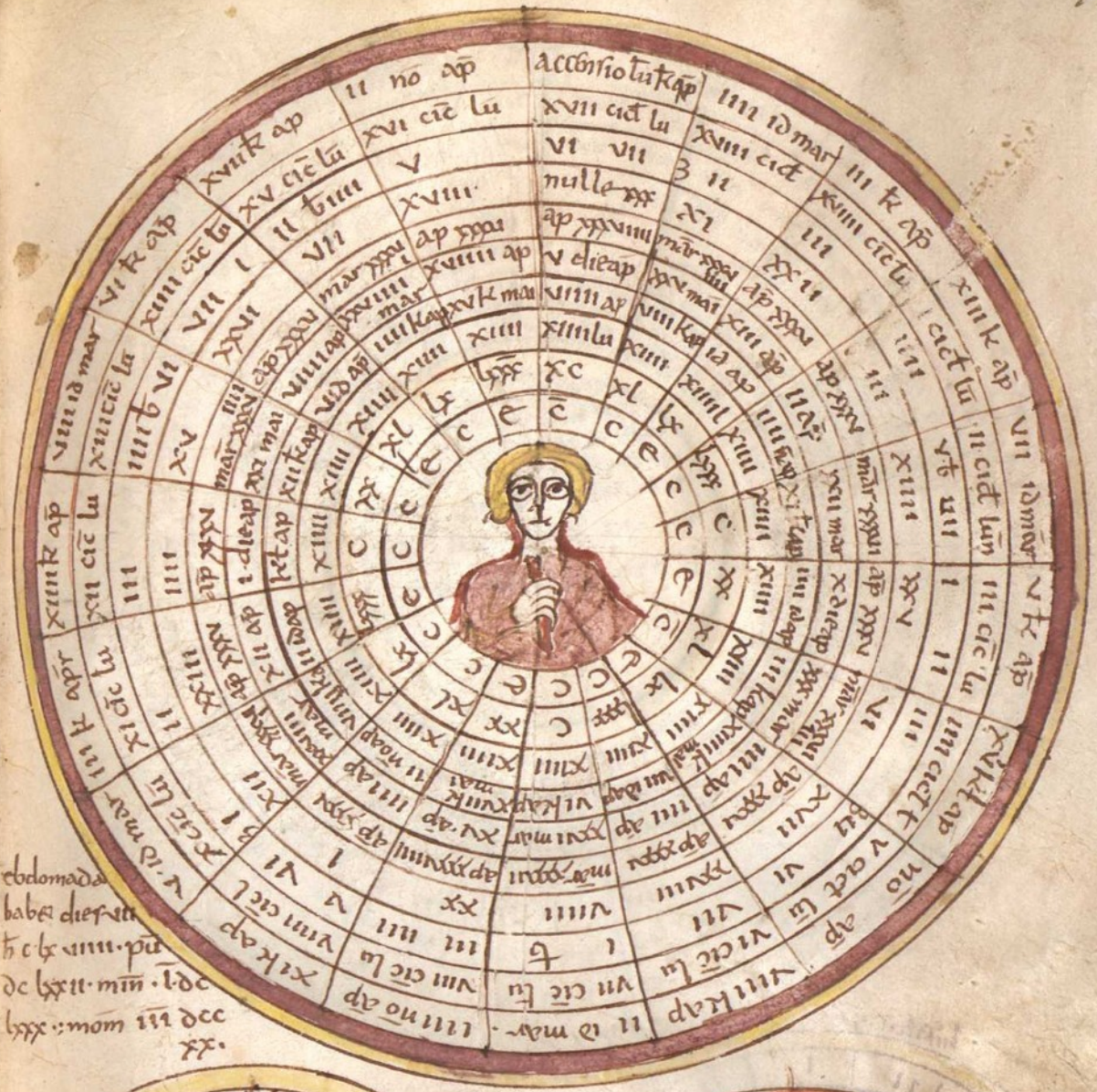
19 Jahre

Vollmond
5. Dezember 2044
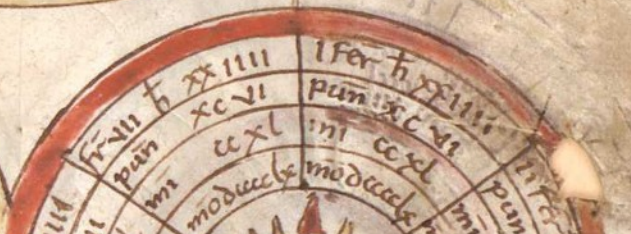


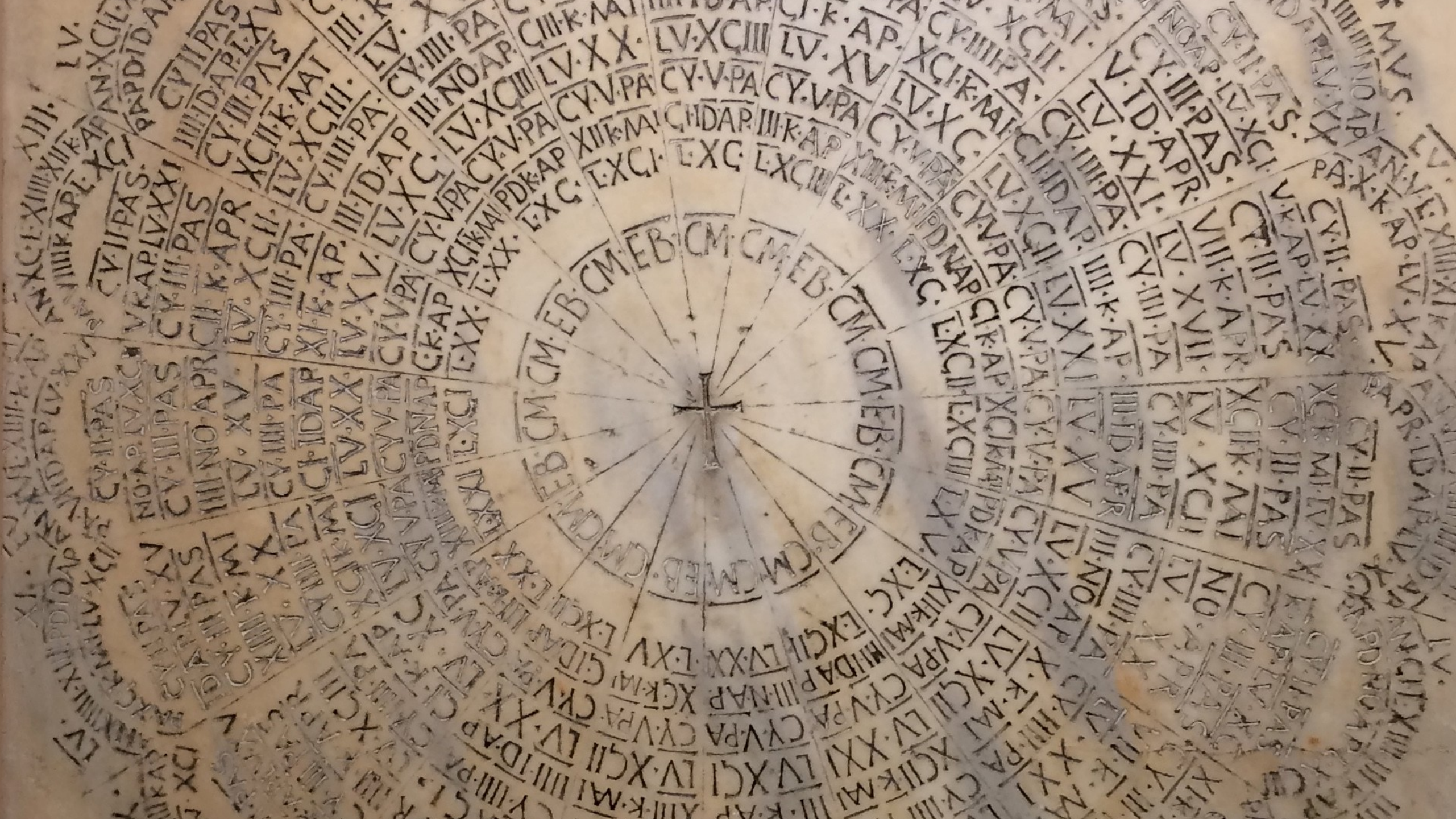

hoc modo


ianuar
februar
martius
aprilis
maius
iunius
iulius
augustus
september
october
november
decemb
hic sole



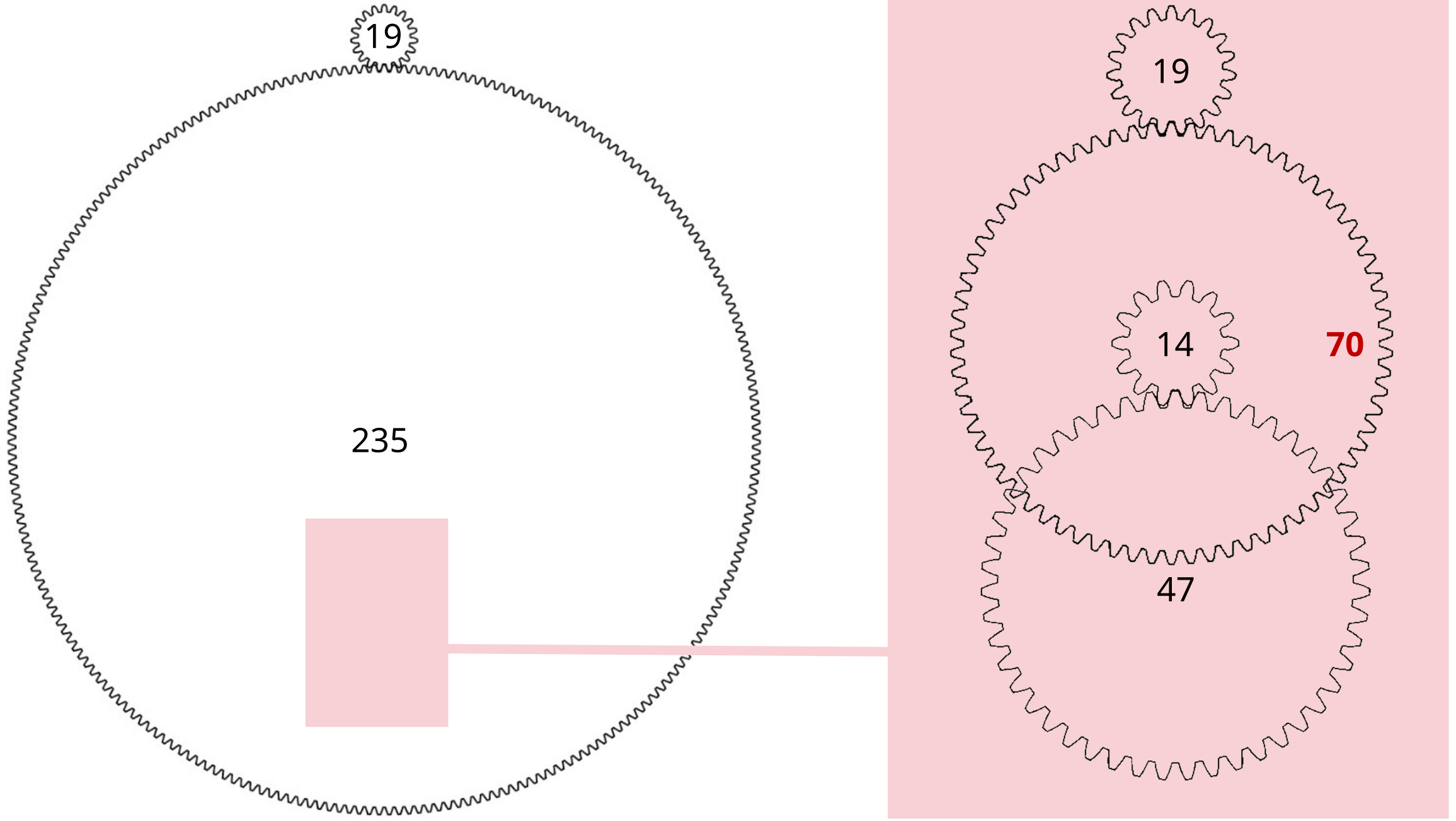




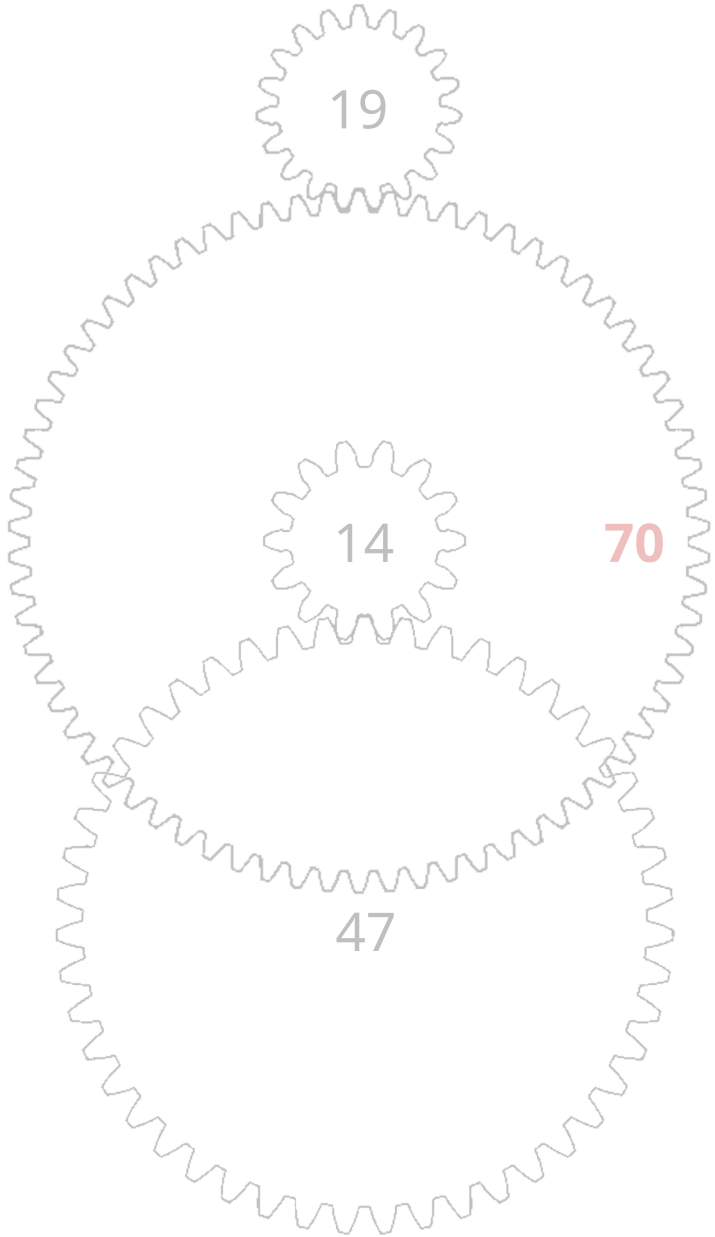


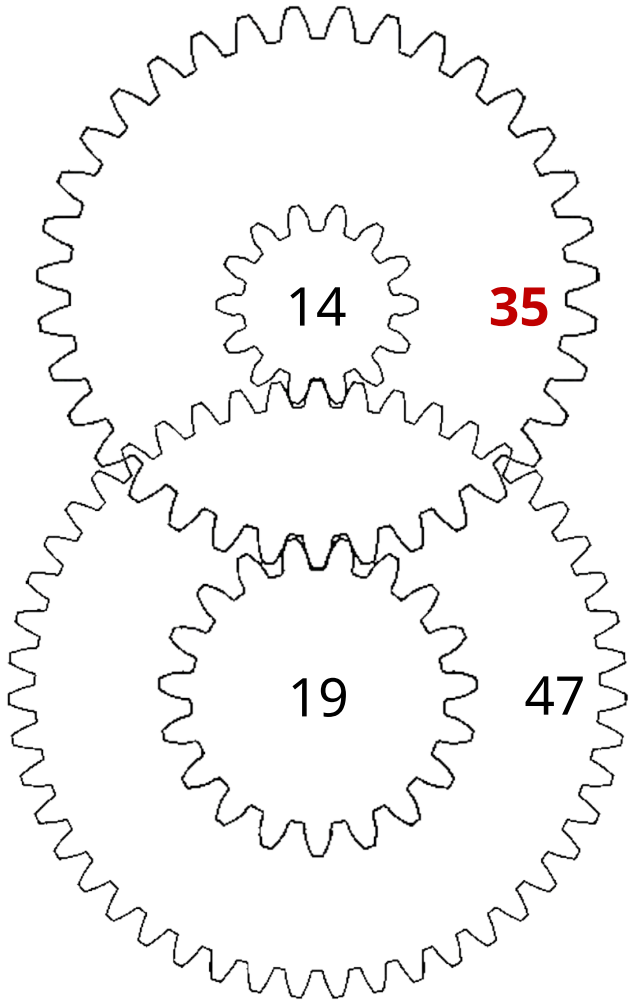
CALENDARIUM PERPETUUM.




19
235
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70
47




19
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meton

virtual mechanical moon
and eclipse calculator



animate

current

meton

virtual mechanical moon
and eclipse calculator

animate

current

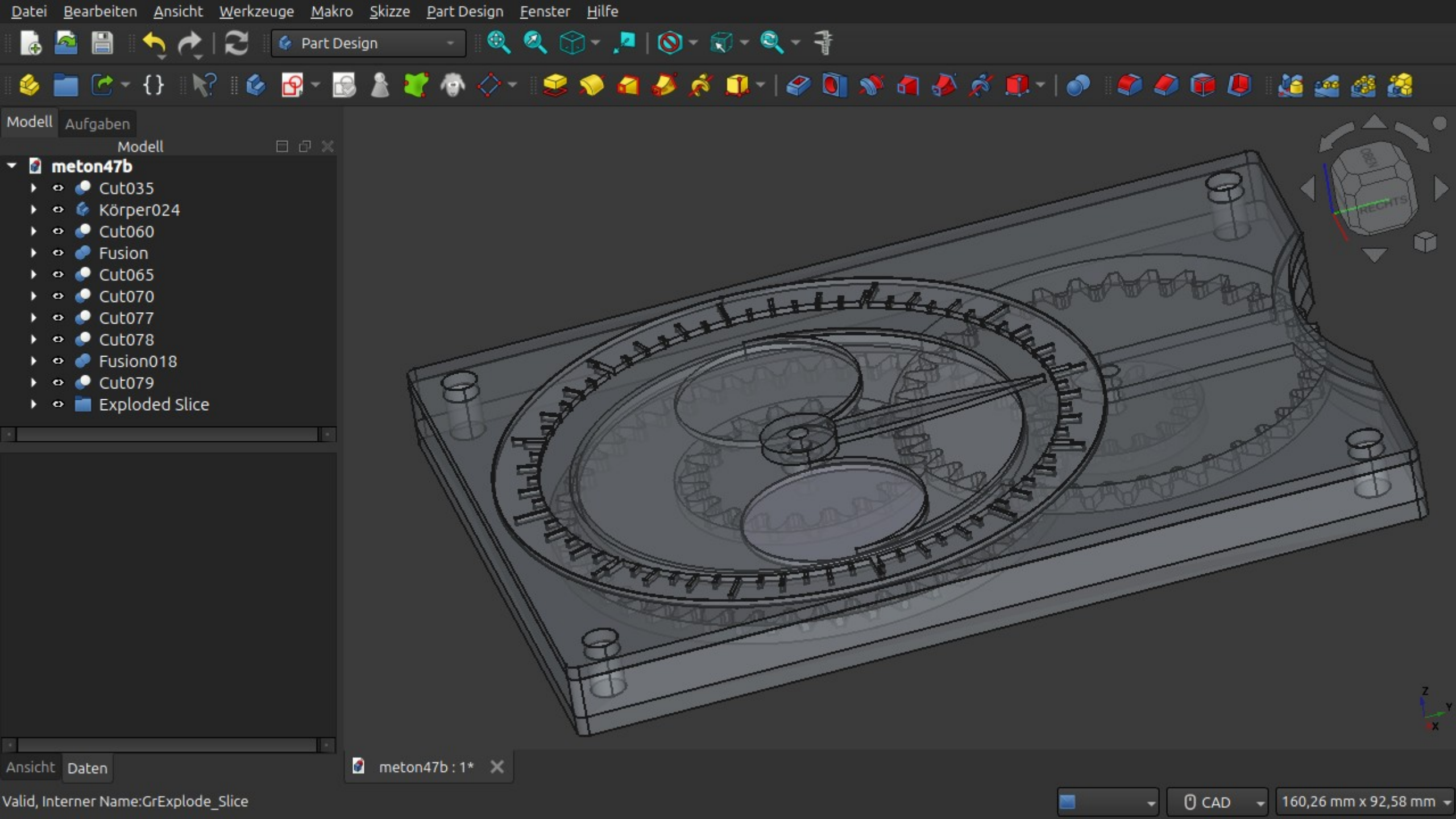


thomasweibel.ch/meton








Datei Bearbeiten Ansicht Werkzeuge Makro Skizze Part Design Fenster Hilfe
Part Design
Modell Aufgaben
Modell
meton47b
Cut035
Körper024
Cut060
Fusion
Cut065
Cut070
Cut077
Cut078
Fusion018
Cut079
Exploded Slice
Ansicht Daten
meton47b : 1*
Valid, Interner Name:GrExplode_Slice
CAD
160,26 mm x 92,58 mm


Jan
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Nov
Dec

From Antiquity to 3D Modeling: The Moon Machine

Thomas Weibel*[1]

[1] *Prof. em., University of Applied Sciences of the Grisons, Pulvermühlestr. 57, 7000 Chur, Switzerland*

Abstract

Observing the lunar cycles has been relevant to humankind for millennia, and already in ancient Babylon their fundamental laws were discovered: 19 solar years correspond to almost exactly 235 synodic lunar months or full cycles of moon phases. This so-called Metonic cycle provides a framework for building lunisolar calendars by synchronizing the solar with the lunar year. The Metonic cycle can be visualized using the machine metaphor, and turned into a virtual online and even a mechanical, 3D-printable moon phase calculator.

Keywords

astronomy, moon, lunar phases, metonic cycle, 3d printing, science history

1. Introduction

Across human cultures, observation of the lunar phases has played a central role in timekeeping, providing a natural basis for calendrical systems. Many historical calendars are founded on lunar or lunisolar cycles. Megalithic alignments dating to approximately 4500 BCE were constructed for solar and lunar observation purposes [1], and throughout history a variety of lunar (e.g., Islamic, ancient Roman) and lunisolar (e.g., Babylonian, Chinese, ancient Greek, Jewish) calendars have been in use [2].

The Antikythera Mechanism—an astronomical visualisation and instruction device often attributed to the school of the mathematician and astronomer Poseidonios in Rhodes (135–51 BCE), likely constructed in the 2nd century BCE—demonstrates that ancient Greek scientists were capable of mechanizing the synodic, sidereal, Draconic, and anomalistic lunar cycles [3]. The underlying astronomical principles, including the Metonic cycle [4] and the Draconic period [5], have been known for millennia.

This article addresses the following research questions:

- How can historical astro-mechanical concepts be visualized using contemporary, widely available digital and physical technologies?
- How can their historical significance be effectively demonstrated, and how can the resulting insights be disseminated within educational contexts?

Today, advanced interactive visualization techniques and 3D printing technology have become widely accessible. The paper will demonstrate that these tools enable the construction of lunisolar calendars based on principles derived from ancient astronomy that remain astonishingly accurate to this date. A mixed-methods design was adopted to translate the historical concepts into both an interactive web application and a 3D-printable mechanical device. Ancient schematics were matched against present-day mechanical engineering principles, which were then formalized into computational models needed for implementing in HTML 5/Javascript, enabling browser-based simulation and user interaction. In parallel, a parametric CAD model was developed to embody the same principles in physical form, with schematics derived directly from relevant historical mechanisms. The resulting digital, web-based, and mechanical artifacts were made available as open data to ensure unrestricted access for educators and researchers worldwide.

7th International Conference on Creative\Media/Technologies (IConCMT), November 26-27, 2025, University of Applied Sciences St. Pölten, Austria

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2. The Metonic cycle

Meton of Athens was a Greek mathematician and astronomer in the fifth century BCE. He is credited with the construction of a large sundial, the remnants of which are still extant. Although none of his written works have survived, Meton—like many scholars of his time—most likely investigated the relationship between solar and lunar timekeeping. He is best known due to the Metonic cycle, named in his honor: a 19-year period that provides a close synchronization of the solar with the lunar year.

The relationship between the solar and lunar cycles is inherently complex. A solar year has a mean duration of approximately 365.242 days, whereas a synodic lunar month—the interval between two successive identical lunar phases—lasts about 29.53 days. Harmonizing these two incommensurate periods represents a fundamental mathematical challenge for calendrical computation.

This difficulty was addressed through the discovery of the Metonic cycle. As early as the eighth century BCE, Babylonian astronomers recognized that lunar phases (e.g., new or full moon) recur on the same calendar dates at intervals of 19 years. In effect, the Moon returns to nearly the same phase on the same day of the solar year after each 19-year period. For instance, the last full moon of 2025 occurred on 5 December, as it did 19 years earlier, in 2006, and as it will again in 2044.

The Metonic cycle corresponds closely to 235 synodic months and deviates by approximately one day every 218.768 years [6].

$$\frac{235^{\,lunar\ months}}{19^{\,solar\ years}} = 12.368421053^{\,lunar\ months/\ year}$$

Despite this fundamental insight, the computation of lunar and solar calendars remained challenging until the 3rd and 2nd centuries BCE, when Greek astronomers and engineers developed the Antikythera Mechanism, an astronomical visualisation and instruction device [7] crafted from low-tin bronze, capable of mechanically simulating lunar cycles [8] and likely the positions of the planets known to ancient Greek astronomy. The remains of the mechanism were recovered in 1901 by Greek sponge divers, and today a whole number of fragments (out of a total of 82) are on display at the National Archaeological Museum in Athens.

Recent investigations using high-resolution, high-voltage X-ray computed tomography [9] and Polynomial Texture Mapping (PTM) have revealed the functions of the device. The studies confirm that the front dial displayed the sidereal and synodic lunar cycles, while the rear dials represented the Metonic cycle (including the four-year Callippic cycle), the Saros cycle (including the three-year Exeligmos cycle), and the four-year cycle of the Panhellenic Games, the latter constituting the only non-astronomical information processed by the device.

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