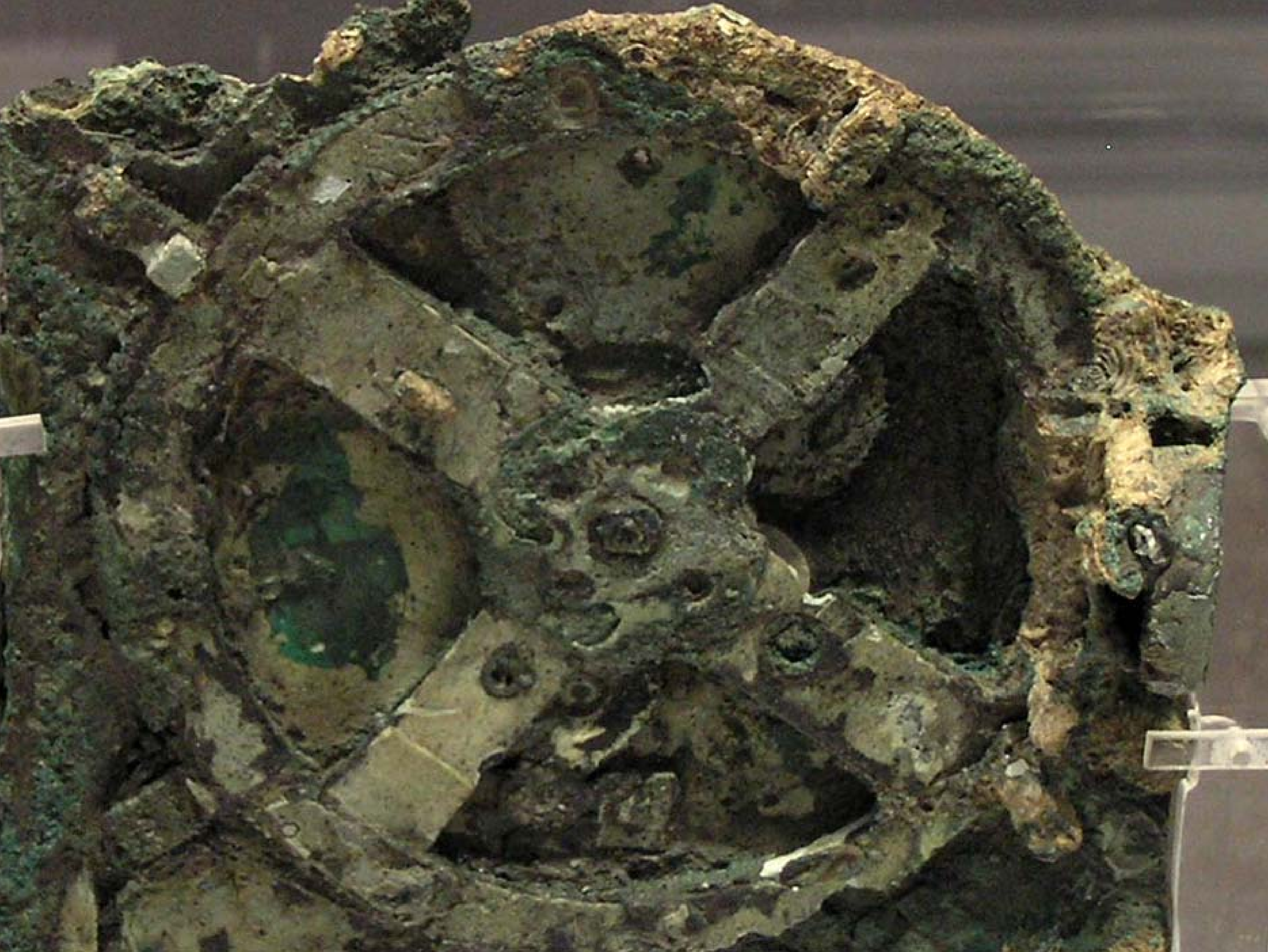
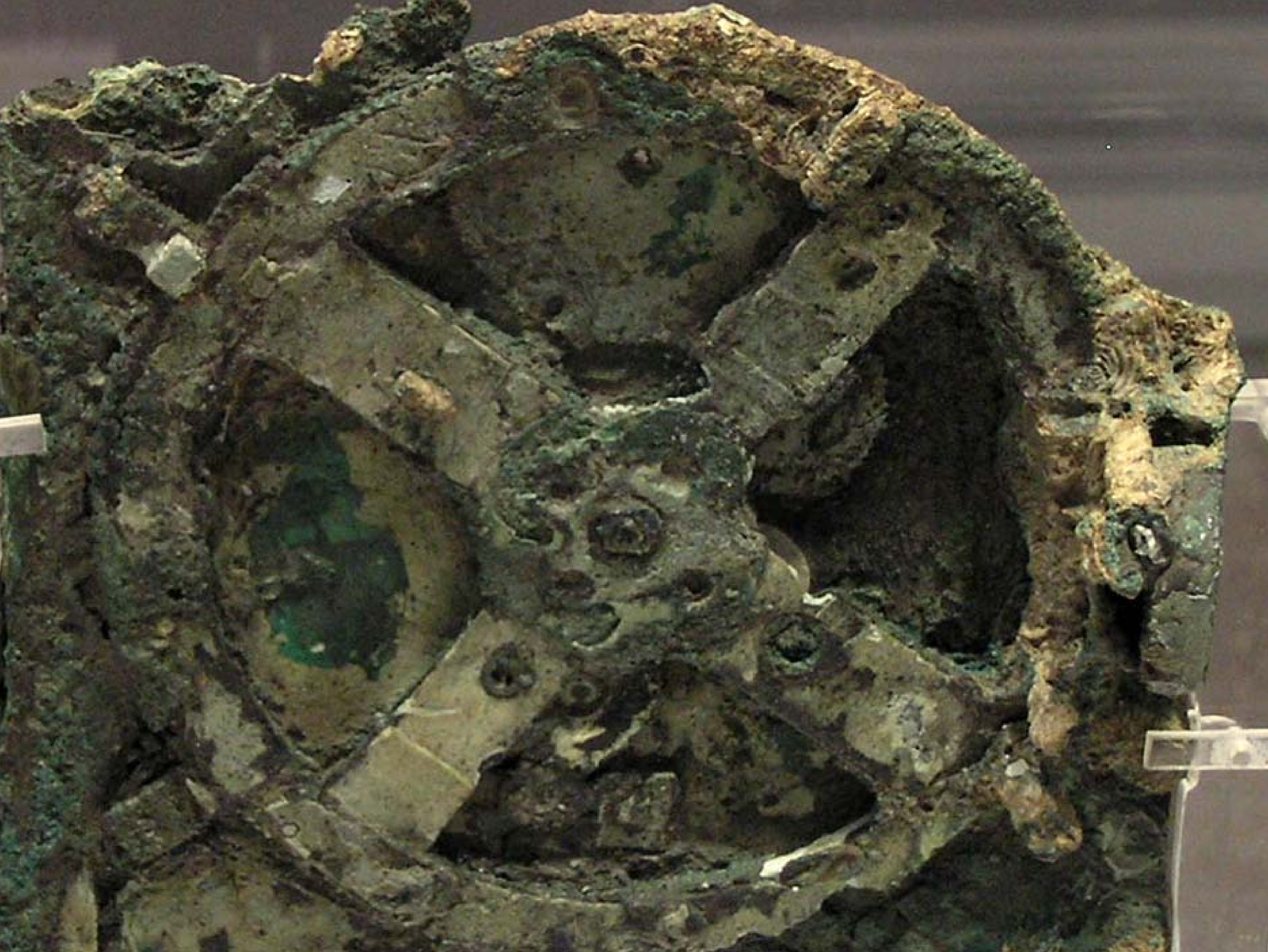
The Antikythera Mechanism: Hacking with Gears

Diomidis Spinellis
Professor of Software Engineering
Department of Management Science and Technology
Athens University of Economics and Business
http://www.spinellis.gr





Lattice Semiconductor Corporation

High-Speed PCB Design Considerations

December 2006 Technical Note TN1033

PCB Design Checklist

1. Use 100 ohm differential impedance pairs on PCB. Controlled impedance lines should be specified in the PCB layout mechanical drawing.

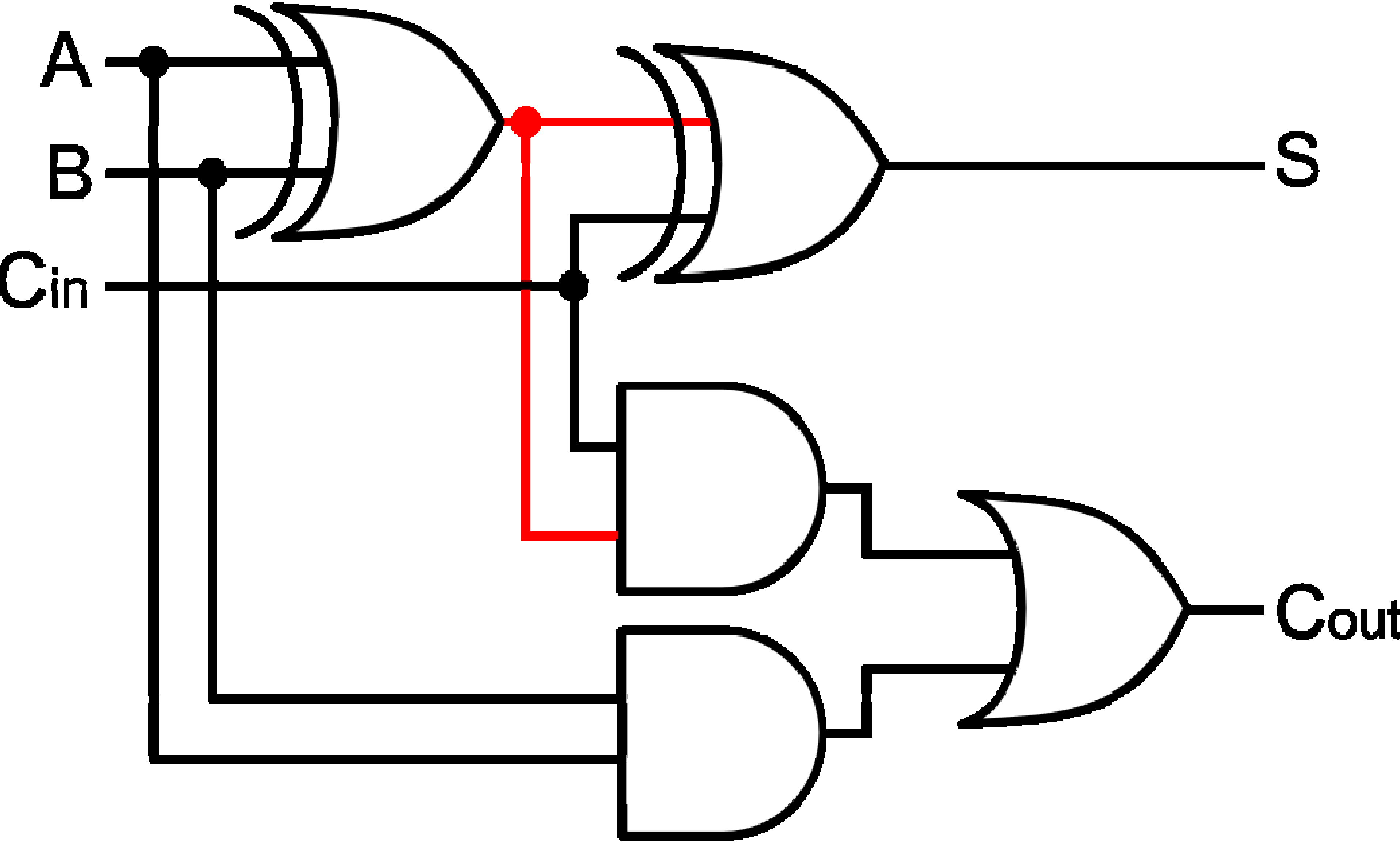
2. Match trace lengths in a pair with tolerance of 20% of the signal rise/fall time.

3. Use connectors that are designed and characterized at the highest data frequency. (Vendors should provide characterization and model data.)

4. Use stripline construction with ground/power planes above and below the differential pairs. The ground and power planes also provide return paths for signal currents.

5. Use edge-coupled pairs in PCBs; try to avoid broadside coupled pairs.

6. Use 3 S separation rules between pairs to avoid crosstalk and excess coupling. Use offset stripline routing to get higher density of differential pairs with each routing layer running orthogonal to each other.


A
B
Cin
S
Cout

Sine/Cosine Look-Up Table v5.0

DS275 April 28, 2005 — Product Specification

Features

- Drop-in module for Virtex™, Virtex-E, and Virtex-II, Virtex-II Pro, Virtex-4, Spartan™-II, Spartan-IIE, Spartan-3, and Spartan-3E FPGAs
- User specified option for table value storage in Distributed/Block Memory
- Supports THETA input widths of 3 to 10 bits for Distributed ROM and 3 to 16 bits for Block ROM
- Supports output Sine/Cosine widths of 4 to 32 bits
- Supports negative Sine/Cosine outputs

Functional Description

The Sine/Cosine module accepts an unsigned input value THETA and produces two's complement outputs of SINE (THETA) and/or COSINE (THETA). The user controls the input THETA width and output SINE and /or COSINE width values.

Equation 1 defines the relationship between the integer input angle THETA supplied to the core (refer to Figure 1) and the actual radian angle Θ

$$\theta = \text{THETA}\frac{2\Pi}{2^{\text{THETA\_WIDTH}}}\text{radians} \qquad \text{Eq. 1}$$

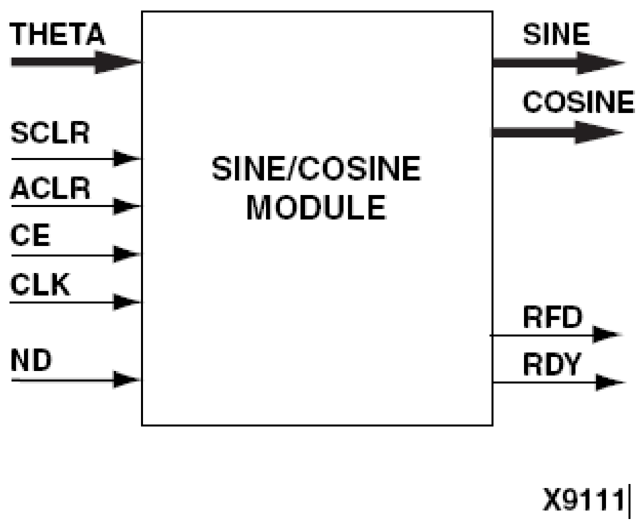
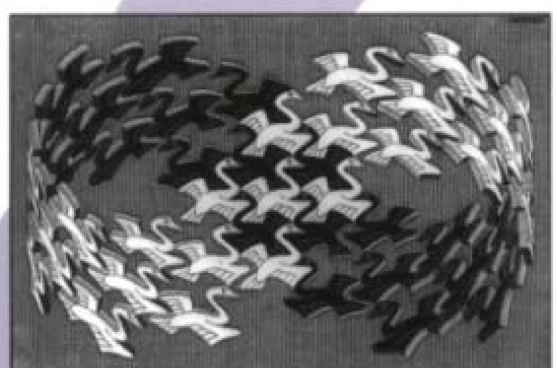


Figure 1: **Core Schematic Symbol**

Design Patterns

Elements of Reusable Object-Oriented Software

Erich Gamma
Richard Helm
Ralph Johnson
John Vlissides



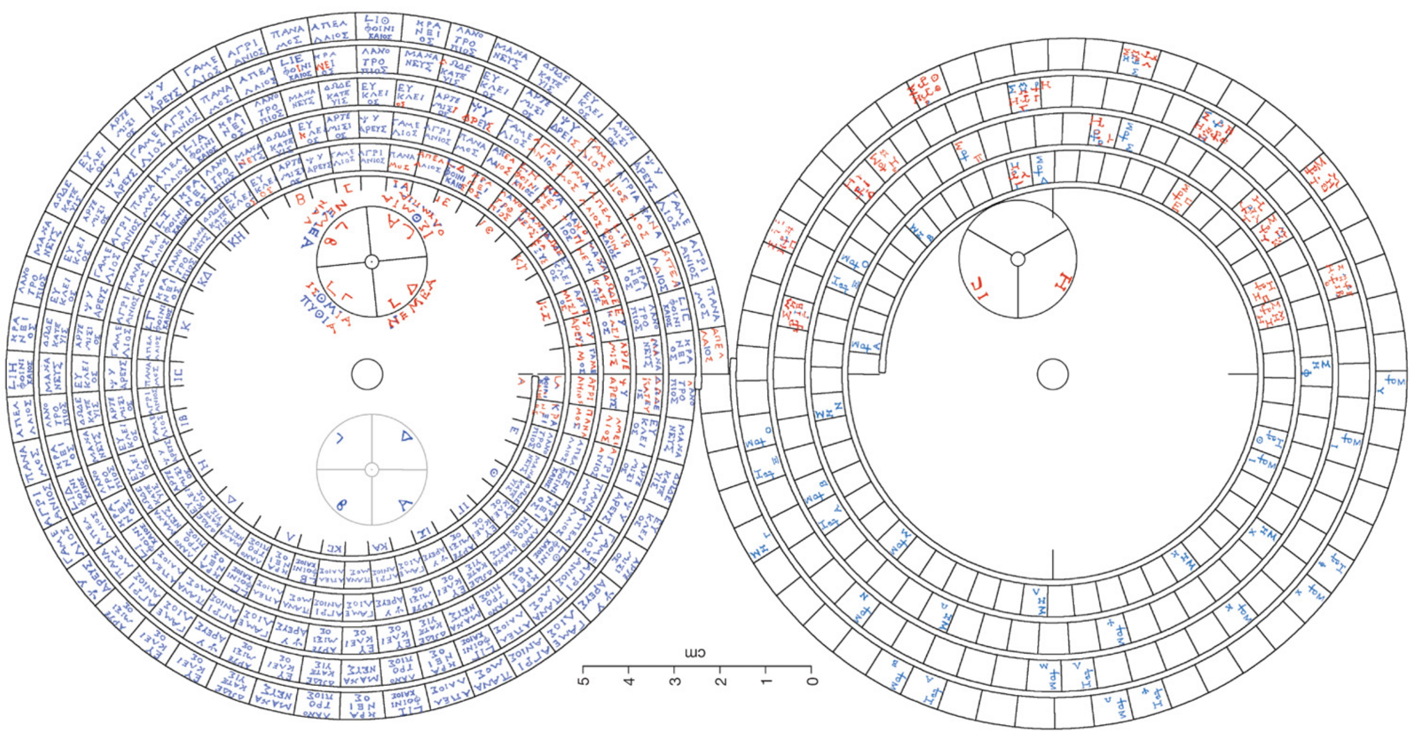
Cover art © 1994 M.C. Escher / Cordon Art - Baarn - Holland. All rights reserved.

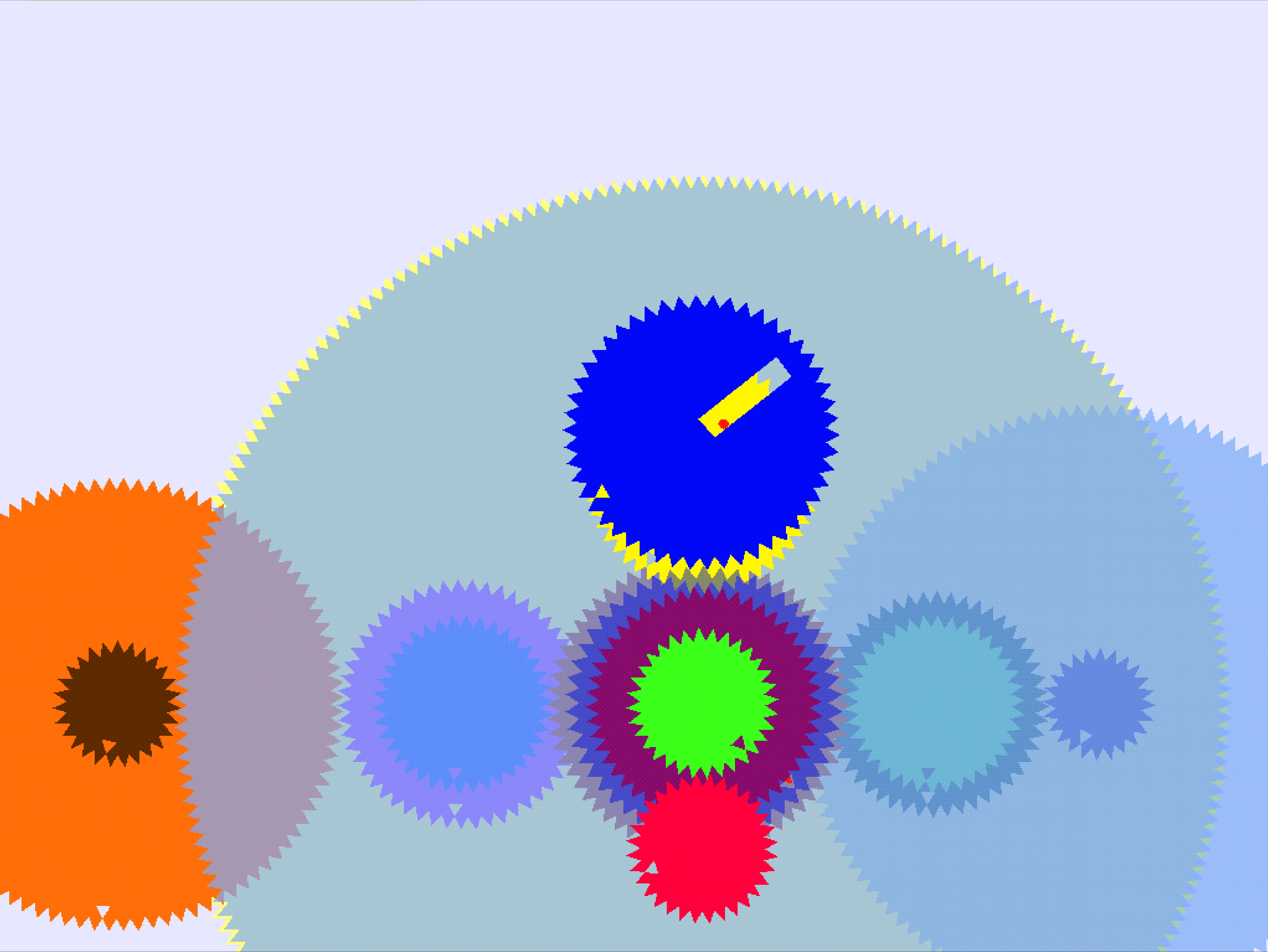
Foreword by Grady Booch

ADDISON-WESLEY PROFESSIONAL COMPUTING SERIES

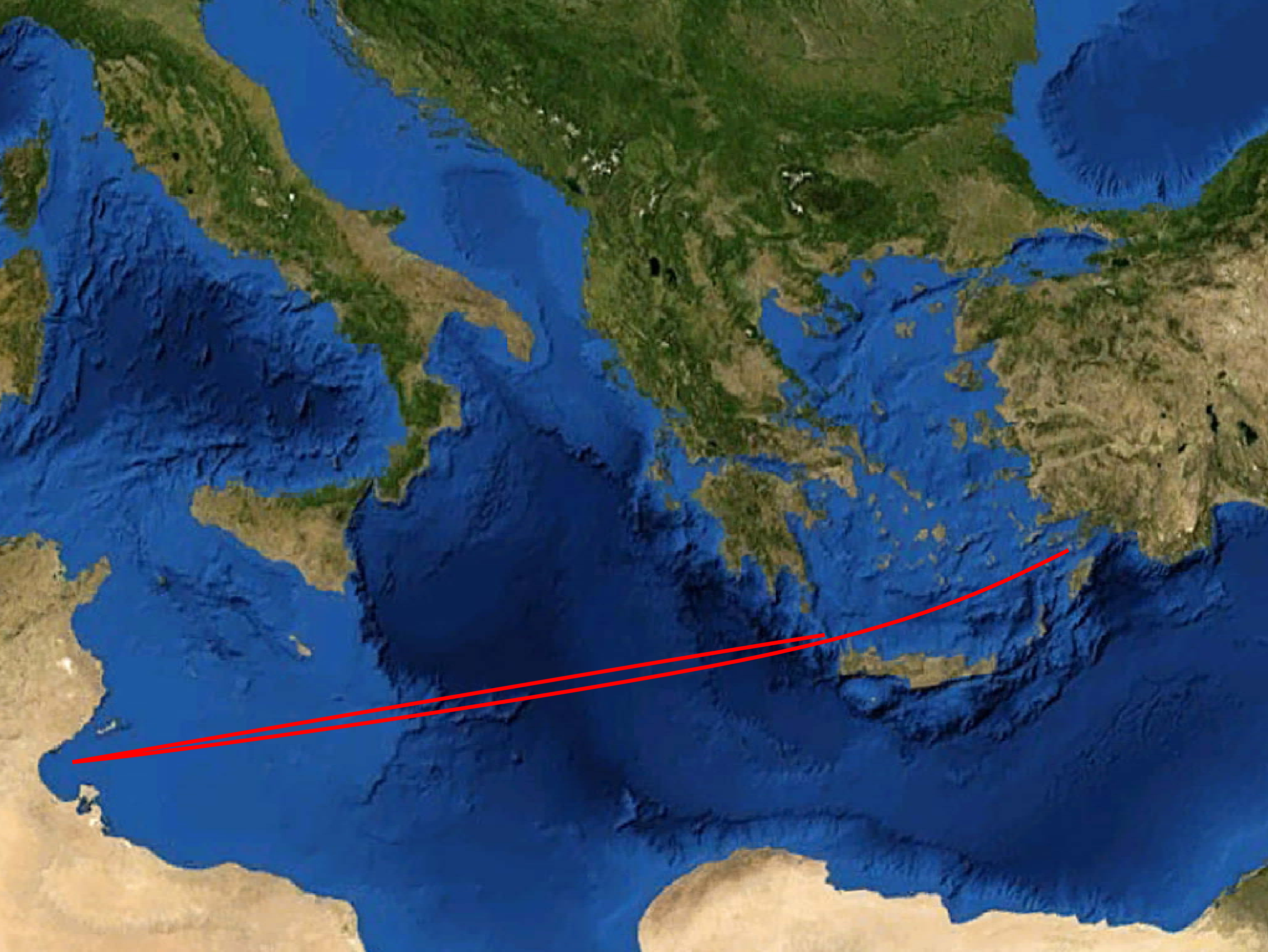
3

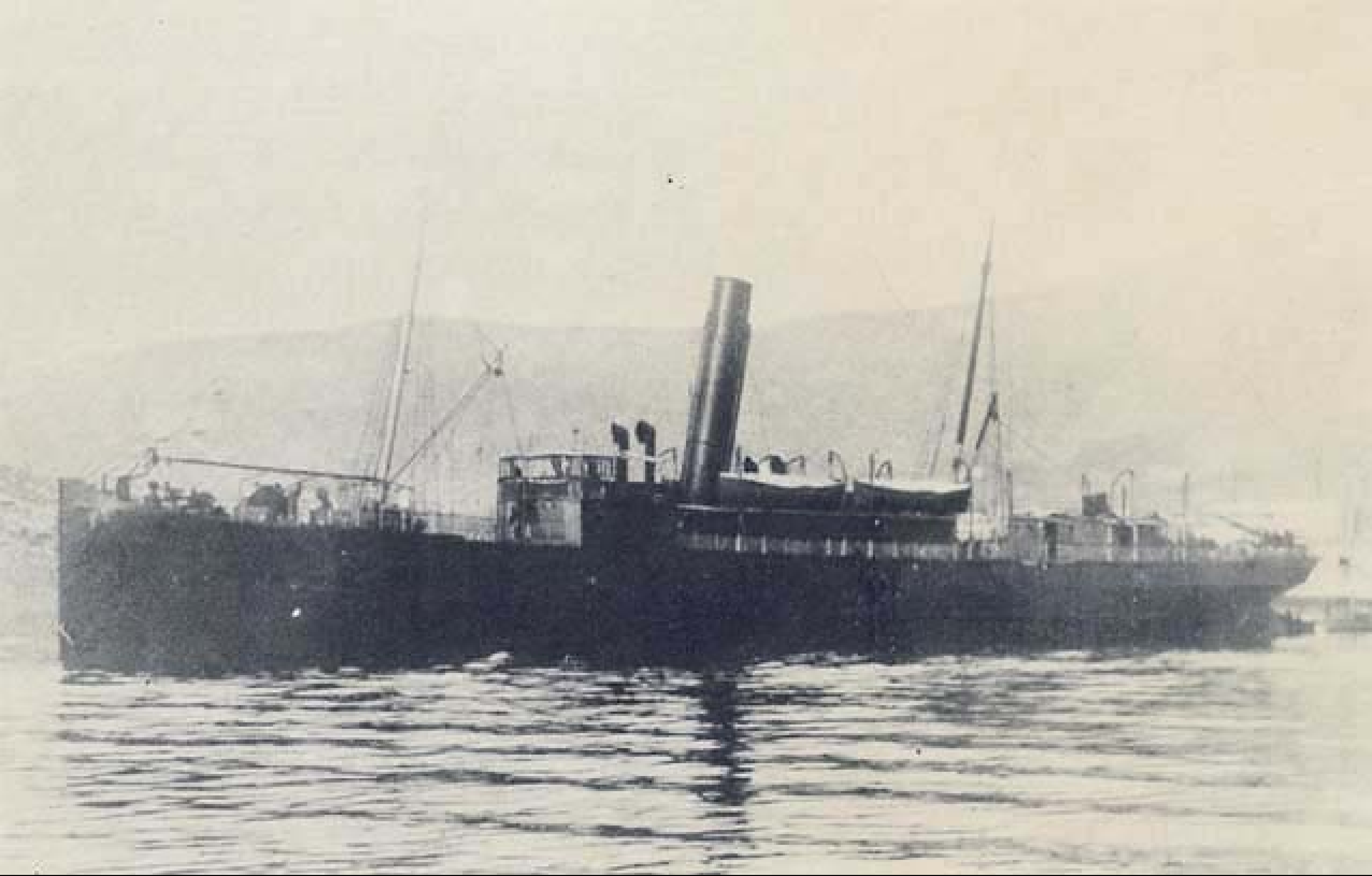
T Freeth *et al.* *Nature* **454**, 614-617 (2008) doi:10.1038/nature07130



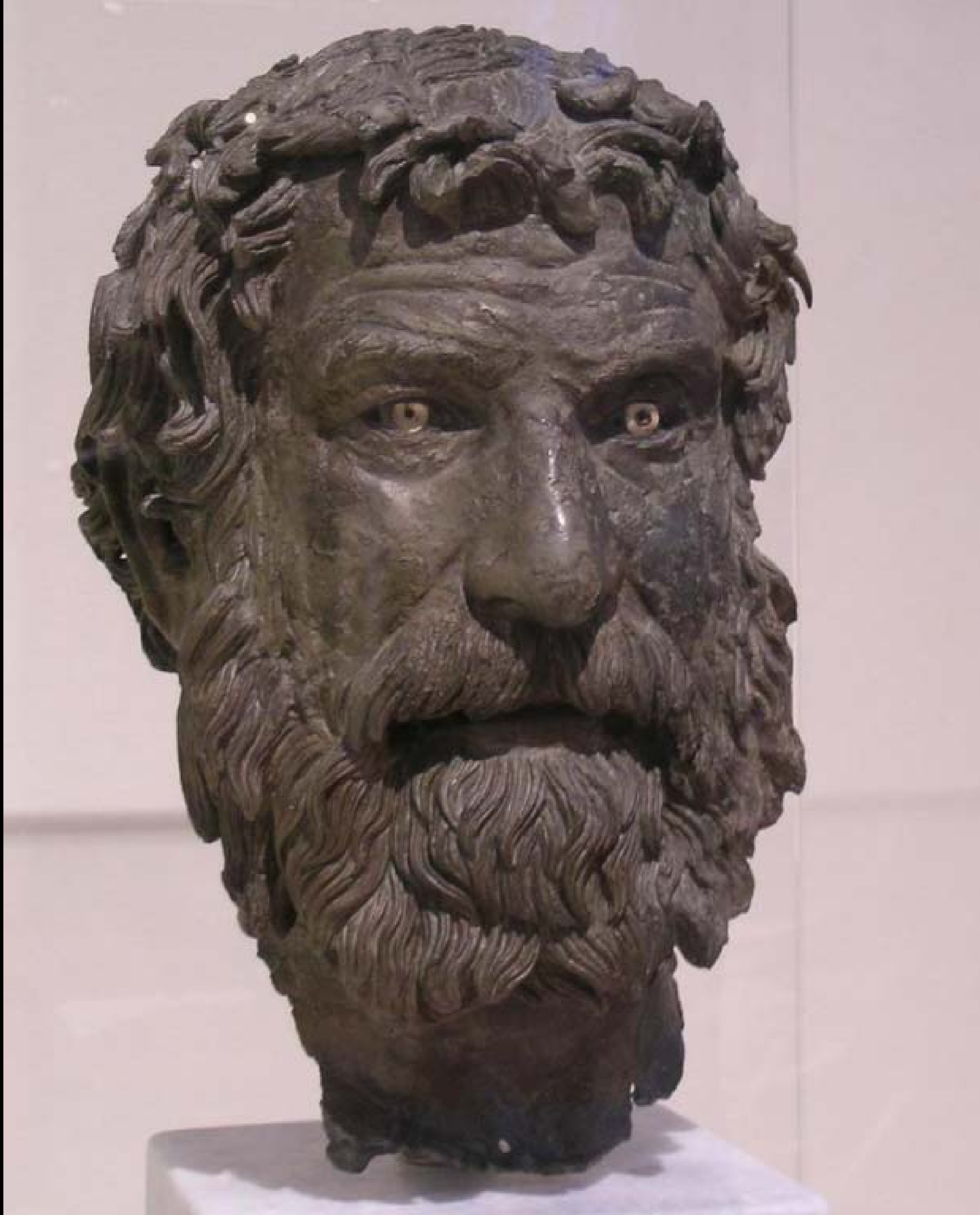


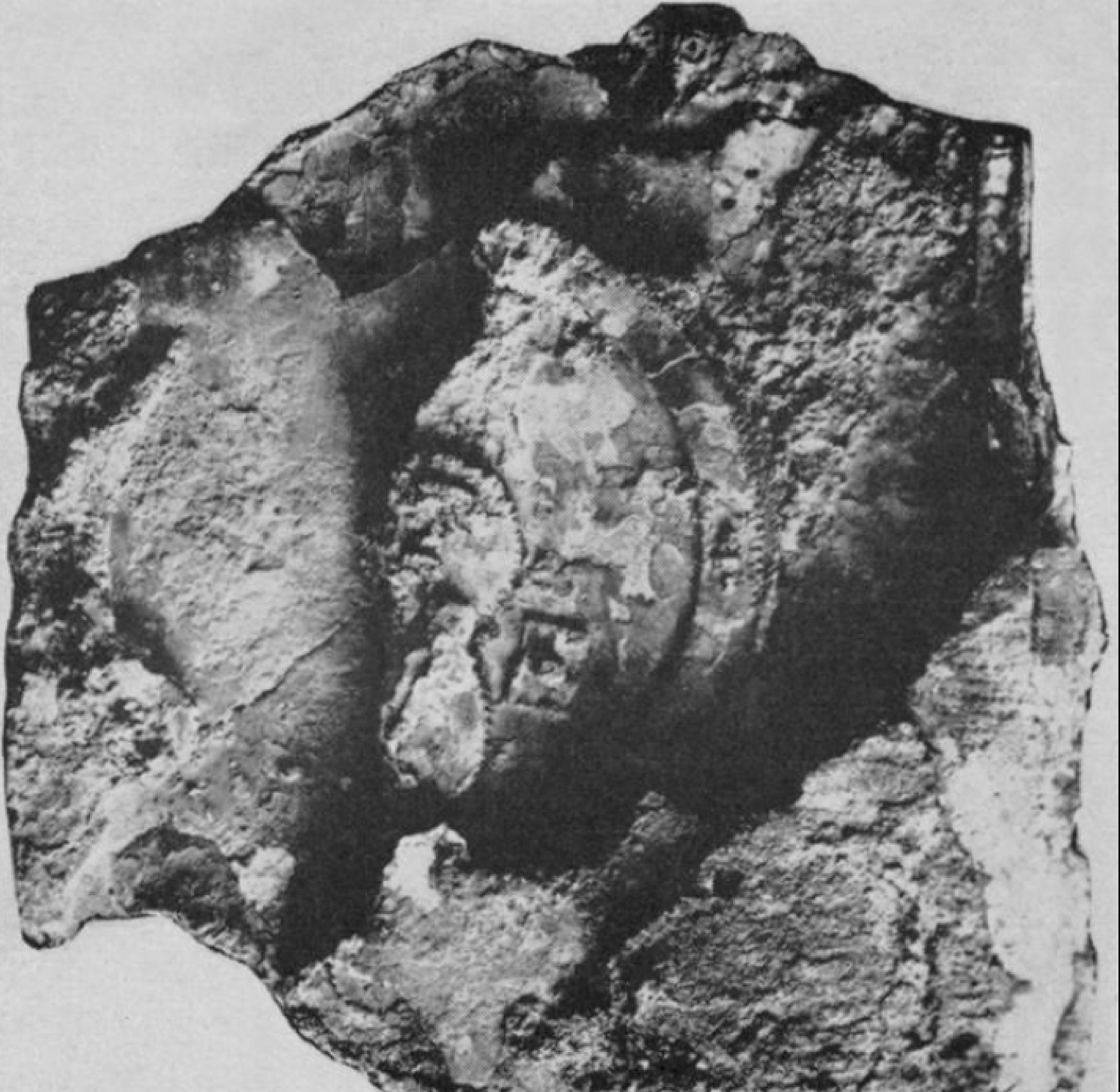
1900

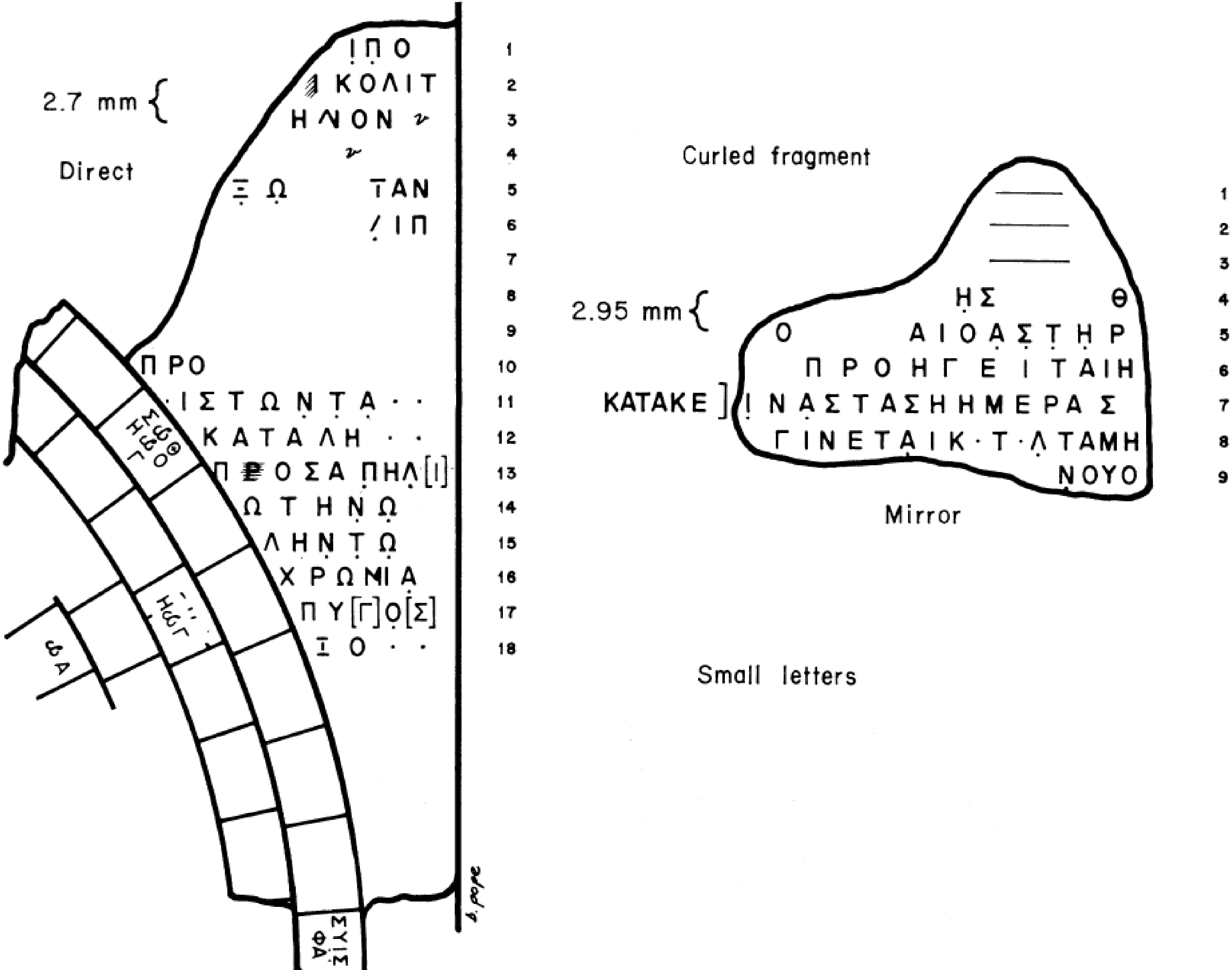





ΣΚΑΦΑΝΔΡΟ
SKAFANDR
(DIVING SUIT
1864-1970







2.7 mm
Direct
ΙΠΟ
ΚΟΛΙΤ
ΗΛΟΝ
ΞΩ ΤΑΝ
ΙΠ
ΠΡΟ
ΙΣΤΩΝΤΑ
ΚΑΤΑΛΗ
ΠΡΟΣΑΠΗΛ[Ι]
ΩΤΗΝΩ
ΛΗΝΤΩ
ΧΡΩΝΙΑ
ΠΥ[Γ]Ο[Σ]
ΞΟ
Curled fragment
2.95 mm
ΗΣ Θ
Ο ΑΙΟΑΣΤΗΡ
ΠΡΟΗΓΕΙΤΑΙΗ
ΚΑΤΑΚΕ] ΙΝΑΣΤΑΣΗΗΜΕΡΑΣ
ΓΙΝΕΤΑΙΚ·Τ·ΛΤΑΜΗ
ΝΟΥΟ
Mirror
Small letters

TRANSACTIONS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY

HELD AT PHILADELPHIA

FOR PROMOTING USEFUL KNOWLEDGE

NEW SERIES—VOLUME 64, PART 7

1974

GEARS FROM THE GREEKS

THE ANTIKYTHERA MECHANISM—A CALENDAR COMPUTER FROM *ca.* 80 B.C.

DEREK DE SOLLA PRICE

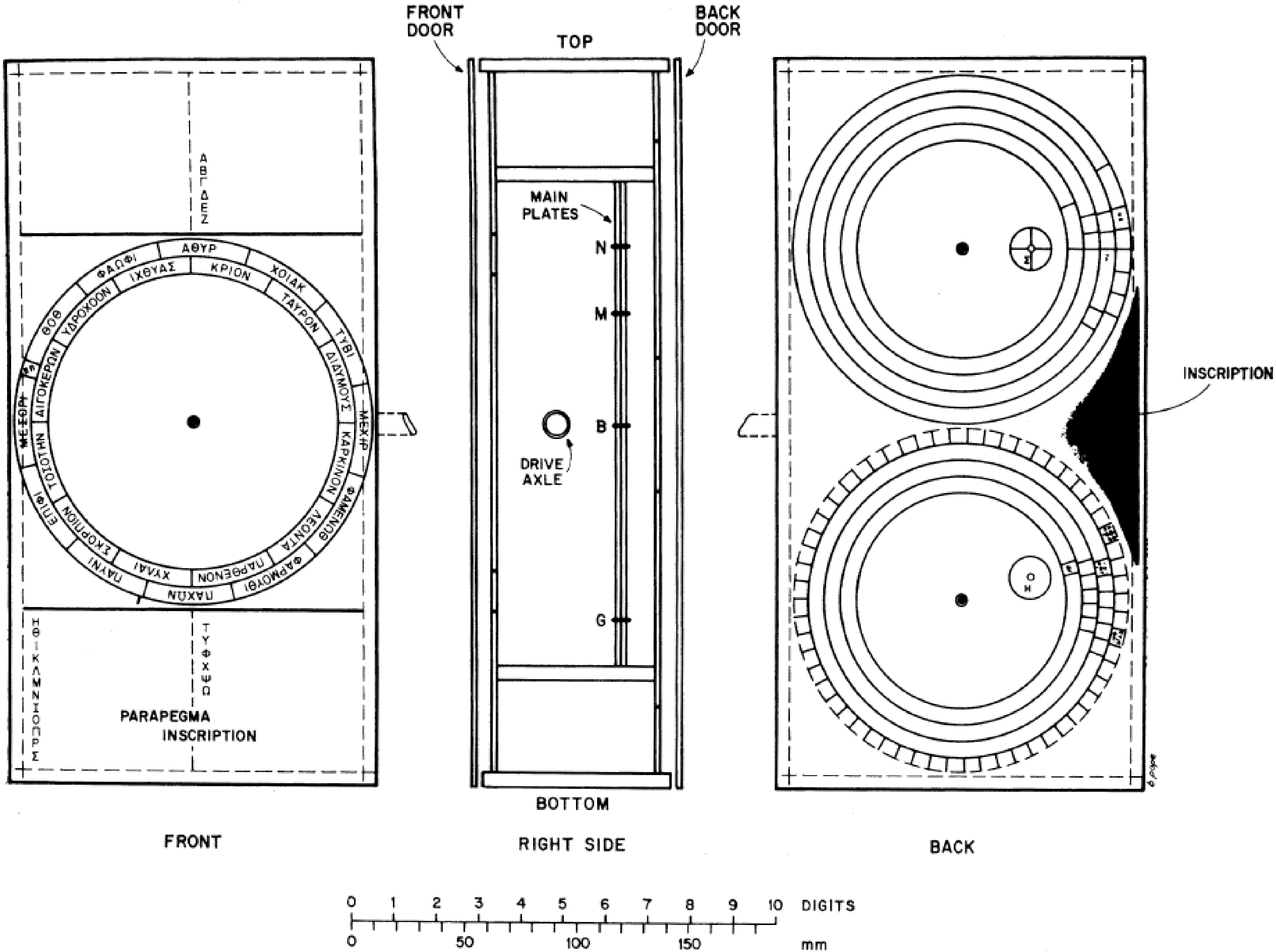
Avalon Professor of History of Science, Yale University

THE AMERICAN PHILOSOPHICAL SOCIETY

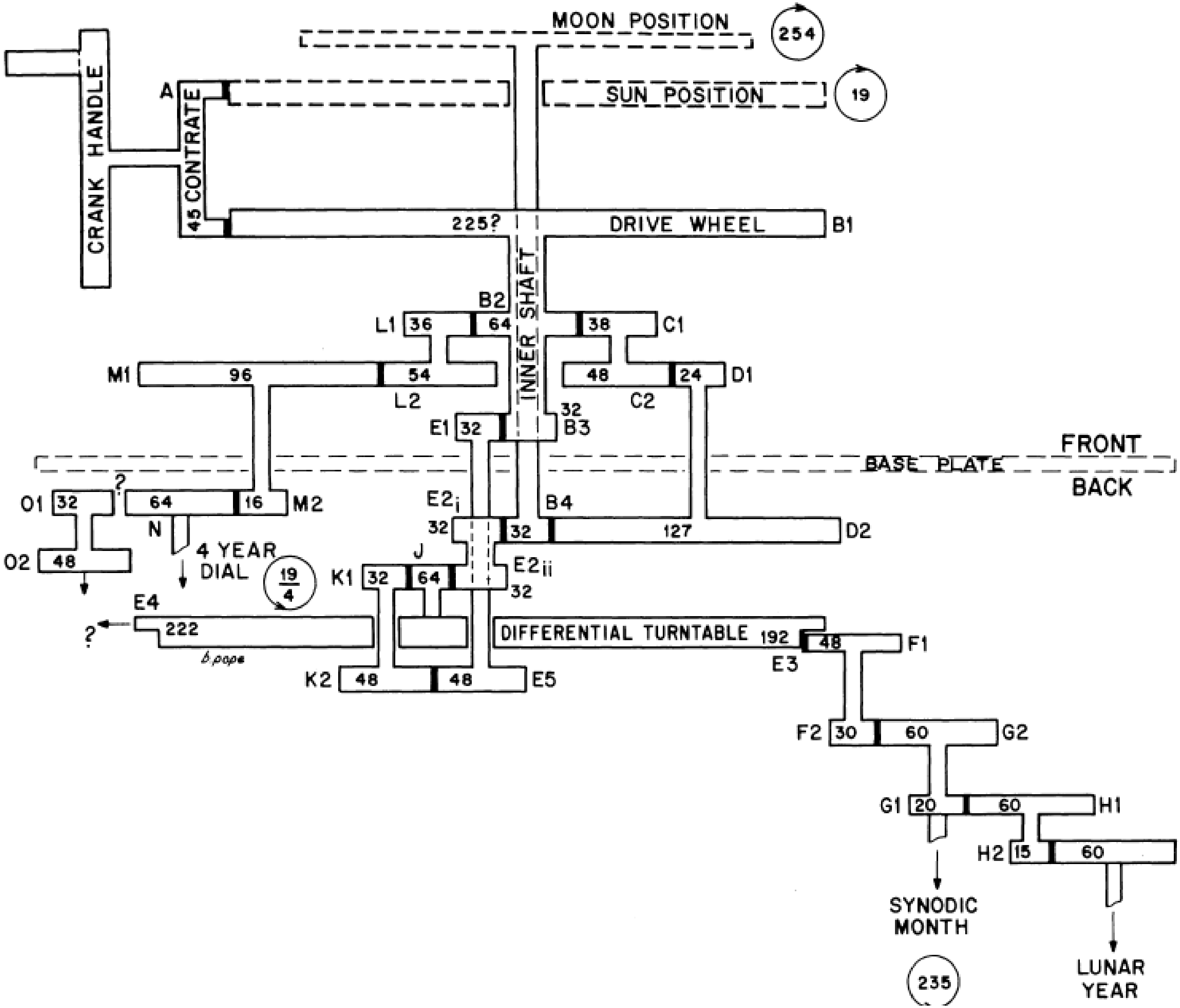
INDEPENDENCE SQUARE

PHILADELPHIA

November, 1974



FRONT DOOR
BACK DOOR
TOP
MAIN PLATES
N
M
B
G
DRIVE AXLE
BOTTOM
INSCRIPTION
Α Β Γ Δ Ε Ζ
ΑΘΥΡ
ΧΟΙΑΚ
ΤΥΒΙ
ΜΕΧΙΡ
ΦΑΜΕΝΩΘ
ΦΑΡΜΟΥΘΙ
ΠΑΧΩΝ
ΠΑΥΝΙ
ΕΠΙΦΙ
ΜΕΣΟΡΗ
ΘΩΘ
ΦΑΩΦΙ
ΚΡΙΟΝ
ΤΑΥΡΟΝ
ΔΙΔΥΜΟΥΣ
ΚΑΡΚΙΝΟΝ
ΛΕΟΝΤΑ
ΠΑΡΘΕΝΟΝ
ΧΗΛΑΙ
ΣΚΟΡΠΙΟΝ
ΤΟΞΟΤΗΝ
ΑΙΓΟΚΕΡΩΝ
ΥΔΡΟΧΟΟΝ
ΙΧΘΥΑΣ
Η Θ Ι Κ Λ Μ Ν Ξ Ο Π Ρ Σ
Τ Υ Φ Χ Ψ Ω
PARAPEGMA INSCRIPTION
FRONT
RIGHT SIDE
BACK
0 1 2 3 4 5 6 7 8 9 10 DIGITS
0 50 100 150 mm


MOON POSITION
254
SUN POSITION
19
CRANK HANDLE
A
45 CONTRATE
225?
DRIVE WHEEL
B1
INNER SHAFT
B2
L1 36
64
38
C1
M1
96
54
L2
48
C2
24
D1
E1 32
32
B3
FRONT
BASE PLATE
BACK
O1 32
?
64
16
M2
E2i
B4
N
32
32
127
D2
O2 48
4 YEAR DIAL
19/4
J
K1 32
64
E2ii
32
E4
?
222
b.pope
DIFFERENTIAL TURNTABLE
192
48
F1
E3
K2 48
48
E5
F2 30
60
G2
G1 20
60
H1
H2 15
60
I
SYNODIC MONTH
235
LUNAR YEAR

Home | The Project | The Data | FAQ | Events

Search

Bibliography | Credits | Legal | Contact

YOU ARE HERE The Institutions

The Institutions

The **Research Team** is constituted from people that are (or where) affiliated to the following institutions:

University of Cardiff
National & Kapodistrian University of Athens
Aristotle University of Thessaloniki
National Archaeological Museum
National Bank of Greece Cultural Foundation

Technical Support is provided by:

X-Tek Systems Ltd
Hewlett-Packard Inc.
Images First Ltd
Volume Graphics GmBH
Keele University

www.antikythera-mechanism.gr

Vol 444|30 November 2006|doi:10.1038/nature05357 nature

LETTERS

Decoding the ancient Greek astronomical calculator known as the Antikythera Mechanism

T. Freeth[1,2], Y. Bitsakis[3,5], X. Moussas[3], J. H. Seiradakis[4], A. Tselikas[5], H. Mangou[6], M. Zafeiropoulou[6], R. Hadland[7], D. Bate[7], A. Ramsey[7], M. Allen[7], A. Crawley[7], P. Hockley[7], T. Malzbender[8], D. Gelb[8], W. Ambrisco[9] & M. G. Edmunds[1]

The Antikythera Mechanism is a unique Greek geared device, constructed around the end of the second century BC. It is known[1–9] that it calculated and displayed celestial information, particularly cycles such as the phases of the moon and a luni-solar calendar. Calendars were important to ancient societies[10] for timing agricultural activity and fixing religious festivals. Eclipses and planetary motions were often interpreted as omens, while the calm regularity of the astronomical cycles must have been philosophically attractive in an uncertain and violent world. Named after its place of discovery in 1901 in a Roman shipwreck, the Antikythera Mechanism is technically more complex than any known device for at least a millennium afterwards. Its specific functions have remained controversial[11–14] because its gears and the inscriptions upon its faces are only fragmentary. Here we report surface imaging and high-resolution X-ray tomography of the surviving fragments, enabling us to reconstruct the gear function and double the number of deciphered inscriptions. The mechanism predicted lunar and solar eclipses on the basis of Babylonian arithmetic-progression cycles. The inscriptions support suggestions of mechanical display of planetary positions[9,14,15], now lost. In the second century BC, Hipparchos developed a theory to explain the irregularities of the Moon's motion across the sky caused by its elliptic orbit. We find a mechanical realization of this theory in the gearing of the mechanism, revealing an unexpected degree of technical sophistication for the period.

The bronze mechanism (Fig. 1), probably hand-driven, was originally housed in a wooden-framed case[1] of (uncertain) overall size 315 × 190 × 100 mm (Fig. 2). It had front and back doors, with astronomical inscriptions covering much of the exterior of the mechanism. Our new transcriptions and translations of the Greek texts are given in Supplementary Note 2 ('glyphs and inscriptions'). The detailed form of the lettering can be dated to the second half of the second century BC, implying that the mechanism was constructed during the period 150–100 BC, slightly earlier than previously suggested[1]. This is consistent with a date of around 80–60 BC for the wreck[1,16] from which the mechanism was recovered by some of the first underwater archaeology. We are able to complete the reconstruction[1] of the back door inscription with text from fragment E, and characters from fragments A and F (see Fig. 1 legend for fragment nomenclature). The front door is mainly from fragment G. The text is astronomical, with many numbers that could be related to planetary motions; the word "sterigmos" (ΣΤΗΡΙΓΜΟΣ, translated as 'station' or 'stationary point') is found, meaning where a planet's apparent motion changes direction, and the numbers may relate to planetary cycles. We note that a major aim of this investigation is to set up a data archive to allow non-invasive future research, and access to this will start in 2007. Details will be available on www.antikythera-mechanism.gr.

The back door inscription mixes mechanical terms about construction ("trunnions", "gnomon", "perforations") with astronomical periods. Of the periods, 223 is the Saros eclipse cycle (see Box 1 for a brief explanation of astronomical cycles and periods). We discover the inscription "spiral divided into 235 sections", which is

Figure 1 | The surviving fragments of the Antikythera Mechanism. The 82 fragments that survive in the National Archaeological Museum in Athens are shown to scale. A key and dimensions are provided in Supplementary Note 1 ('fragments'). The major fragments A, B, C, D are across the top, starting at top left, with E, F, G immediately below them. 27 hand-cut bronze gears are in fragment A and one gear in each of fragments B, C and D. Segments of display scales are in fragments B, C, E and F. A schematic reconstruction is given in Fig. 2. It is not certain that every one of the remaining fragments (numbered 1–75) belong to the mechanism. The distinctive fragment A, which contains most of the gears, is approximately 180 × 150 mm in size. We have used three principal techniques to investigate the structure and inscriptions of the Antikythera Mechanism. (1) Three-dimensional X-ray microfocus computed tomography[24] (CT), developed by X-Tek Systems Ltd. The use of CT has been crucial in making the text legible just beneath the current surfaces. (2) Digital optical imaging to reveal faint surface detail using polynomial texture mapping (PTM)[25,26], developed by Hewlett-Packard Inc. (3) Digitized high-quality conventional film photography.

[1]Cardiff University, School of Physics and Astronomy, Queens Buildings, The Parade, Cardiff CF24 3AA, UK. [2]Images First Ltd, 10 Hereford Road, South Ealing, London W5 4SE, UK. [3]National and Kapodistrian University of Athens, Department of Astrophysics, Astronomy and Mechanics, Panepistimiopolis, GR-15783, Zographos, Greece. [4]Aristotle University of Thessaloniki, Department of Physics, Section of Astrophysics, Astronomy and Mechanics, GR-54124 Thessaloniki, Greece. [5]Centre for History and Palaeography, National Bank of Greece Cultural Foundation, P. Skouze 3, GR-10560 Athens, Greece. [6]National Archaeological Museum of Athens, 1 Tositsa Str., GR-10682 Athens, Greece. [7]X-Tek Systems Ltd, Tring Business Centre, Icknield Way, Tring, Hertfordshire HP23 4JX, UK. [8]Hewlett-Packard Laboratories, 1501 Page Mill Road, Palo Alto, California 94304, USA. [9]Foxhollow Technologies Inc., 740 Bay Road, Redwood City, California 94063, USA.

©2006 Nature Publishing Group

nature Vol 454|31 July 2008|doi:10.1038/nature07130

LETTERS

Calendars with Olympiad display and eclipse prediction on the Antikythera Mechanism

Tony Freeth[1,2], Alexander Jones[3], John M. Steele[4] & Yanis Bitsakis[1,5]

Previous research on the Antikythera Mechanism established a highly complex ancient Greek geared mechanism with front and back output dials[1–7]. The upper back dial is a 19-year calendar, based on the Metonic cycle, arranged as a five-turn spiral[1,6,8]. 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[6]. Here we add surprising findings concerning these back dials. Though no month names on the Metonic calendar were previously known, we have now identified all 12 months, which are unexpectedly of Corinthian origin. The Corinthian colonies of northwestern Greece or Syracuse in Sicily are leading contenders—the latter suggesting a heritage going back to Archimedes. Calendars with excluded days to regulate month lengths, described in a first century BC source[9], have hitherto been dismissed as implausible[10,11]. We demonstrate their existence in the Antikythera calendar, and in the process establish why the Metonic dial has five turns. The upper subsidiary dial is not a 76-year Callippic dial as previously thought[8], but follows the four-year cycle of the Olympiad and its associated Panhellenic Games. Newly identified index letters in each glyph on the Saros dial show that a previous reconstruction needs modification[6]. We explore models for generating the unusual glyph distribution, and show how the eclipse times appear to be contradictory. We explain the four turns of the Saros dial in terms of the full moon cycle and the Exeligmos dial as indicating a necessary correction to the predicted eclipse times. The new results on the Metonic calendar, Olympiad dial and eclipse prediction link the cycles of human institutions with the celestial cycles embedded in the Mechanism's gearwork.

This extraordinary astronomical mechanism from about 100 BC employed bronze gears to make calculations based on cycles of the Solar System[1,6] (Supplementary Notes 1). Recovered in 1901 by Greek sponge-divers, its corroded remains are now split into 82 fragments—7 larger fragments (A–G) and 75 smaller fragments (1–75)[6]. Data, gathered in 2005[6,7], included still photography, digital surface imaging[12] and, crucially for this study, microfocus X-ray computed tomography (CT)[6,13] (Figs 1–3)—details are in Supplementary Notes 2 (and at www.antikythera-mechanism.gr).

The main upper back dial is now established as a Metonic calendar[1,6,8] (Figs 1 and 2, Supplementary Box 1). The calendar dial bears inscriptions, only viewable using X-ray CT. We have now identified all 12 months of this calendar (Fig. 2, Supplementary Notes 3), providing conclusive evidence of the regulation of a Greek civil calendar by a Metonic cycle, and clues to the instrument's origin. Whereas the Babylonian calendar followed a Metonic cycle from about 500 BC, it has commonly been assumed that the intercalary months of the numerous lunisolar calendars of the Greek cities were determined arbitrarily—Metonic and Callippic cycles (Supplementary Box 1) only being used by astronomers[14]. The month names on the Metonic spiral, however, belong to a regional calendar unassociated with technical astronomy, suggesting that it may have been common for Greek civil calendars to follow the Metonic cycle by about 100 BC.

The inscriptions show that not only the names and order of the months were regulated, but also which years had 13 months, which month was repeated in these years, and which months had 29 or 30 days. The rules are similar to those given by the first century BC writer Geminos[9], whose accuracy has hitherto been in doubt[10,11]. Years are numbered 1 to 19, and intercalary months are spread as evenly as possible over the cycle, such that each year begins with the first new moon following solstice or equinox[15]. In a Metonic cycle, 110 of the 235 months must have 29 days (Supplementary Box 1). The divisibility of both 110 and 235 by 5 explains the five turns of the spiral: months on the same radius across all five turns are equal in length. The numbers on the inside of each 29-day radius indicate which day in these months is skipped (Fig. 2). The skipped days are spread uniformly at intervals of 64 or 65 days across successive Metonic periods, improving on Geminos' scheme, which had uniform 64-day intervals followed by a run of 74 unskipped days at the end.

The month names and order in Greek regional calendars vary widely[16]. The months on the Mechanism belong to one of the Dorian family of calendars, with practically a complete match (11 or 12 names) with Illyria and Epirus in northwestern Greece and with Corcyra (Corfu)—all Corinthian colonies. The calendars of Corinth and its other important colonial foundation, Syracuse, are poorly

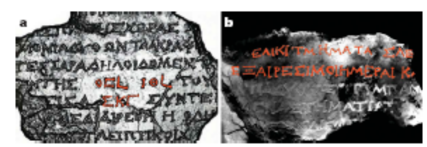
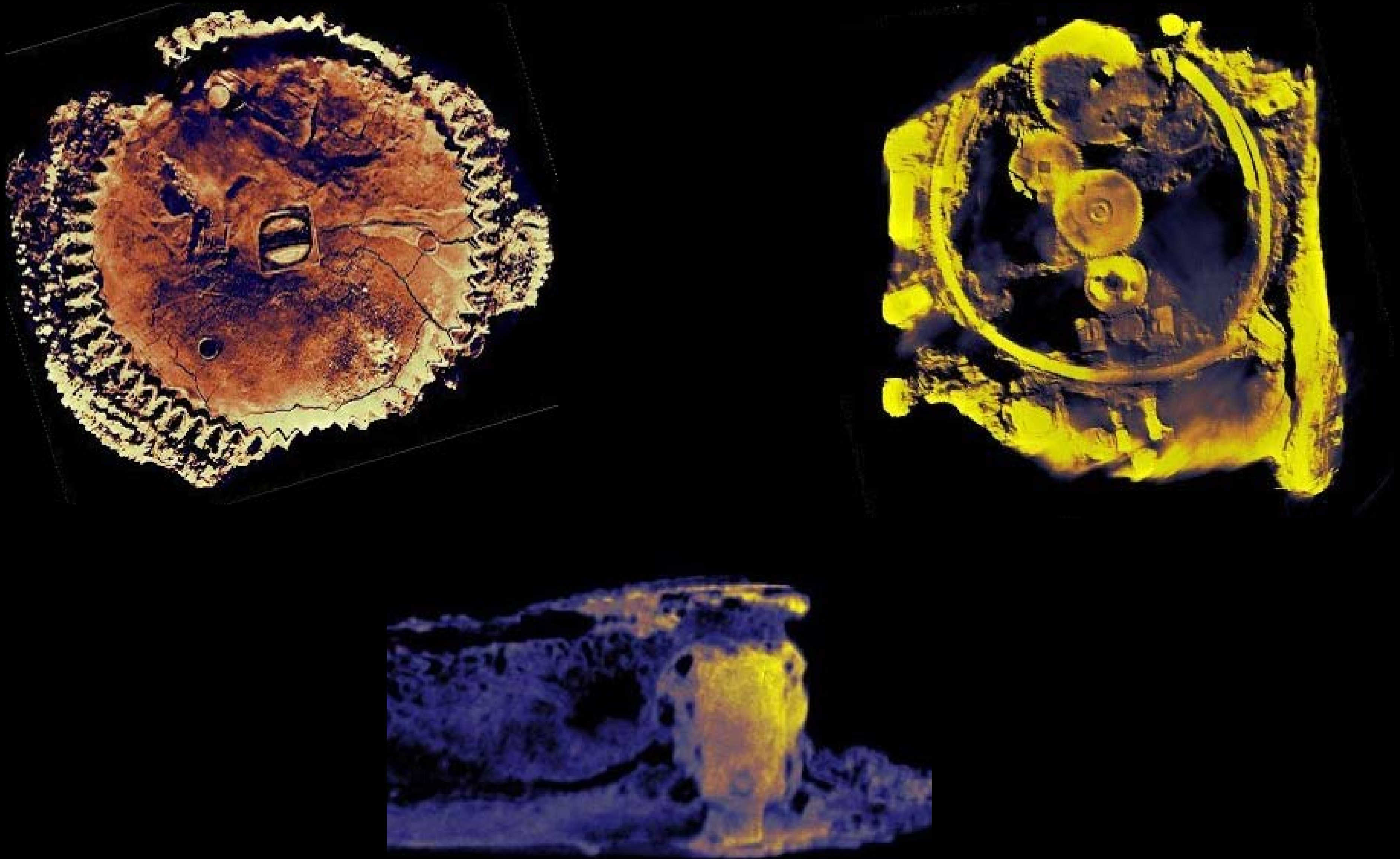


Figure 1 | The 'instruction manual'. Previously identified inscriptions[1,6] reveal remnants of an instruction manual, describing the Mechanism's cycles, dials and functions, as seen in two examples from the Mechanism's back door. **a**, Polynomial texture mapping of fragment 19 shows fine surface detail, with text about 2 mm high. Highlighted in red are "76 years, 19 years" for the Callippic and Metonic cycles (Supplementary Box 1), and "223", for the Saros cycle (Supplementary Box 2). **b**, X-ray CT of fragment E reveals text about 2 mm high. Highlighted are "on the spiral subdivisions 235", confirming the Metonic dial (Supplementary Box 1); and "excluded days 2…", the final "K" presumably standing for the number 20—part of the 22 excluded days round each of the five turns of the Metonic calendar—though "B" that would complete "KB" (22) remains speculative.

[1]Antikythera Mechanism Research Project, 3 Tyrwhitt Crescent, Roath Park, Cardiff CF23 5QP, UK. [2]Images First Ltd, 10 Hereford Road, South Ealing, London W5 4SE, UK. [3]Institute for the Study of the Ancient World, 15 East 84th Street, New York, New York 10028, USA. [4]Department of Physics, University of Durham, Rochester Building, South Road, Durham DH1 3LE, UK. [5]Centre for History and Palaeography, 3, P. Skouze str., GR-10560 Athens, Greece.

©2008 Macmillan Publishers Limited. All rights reserved

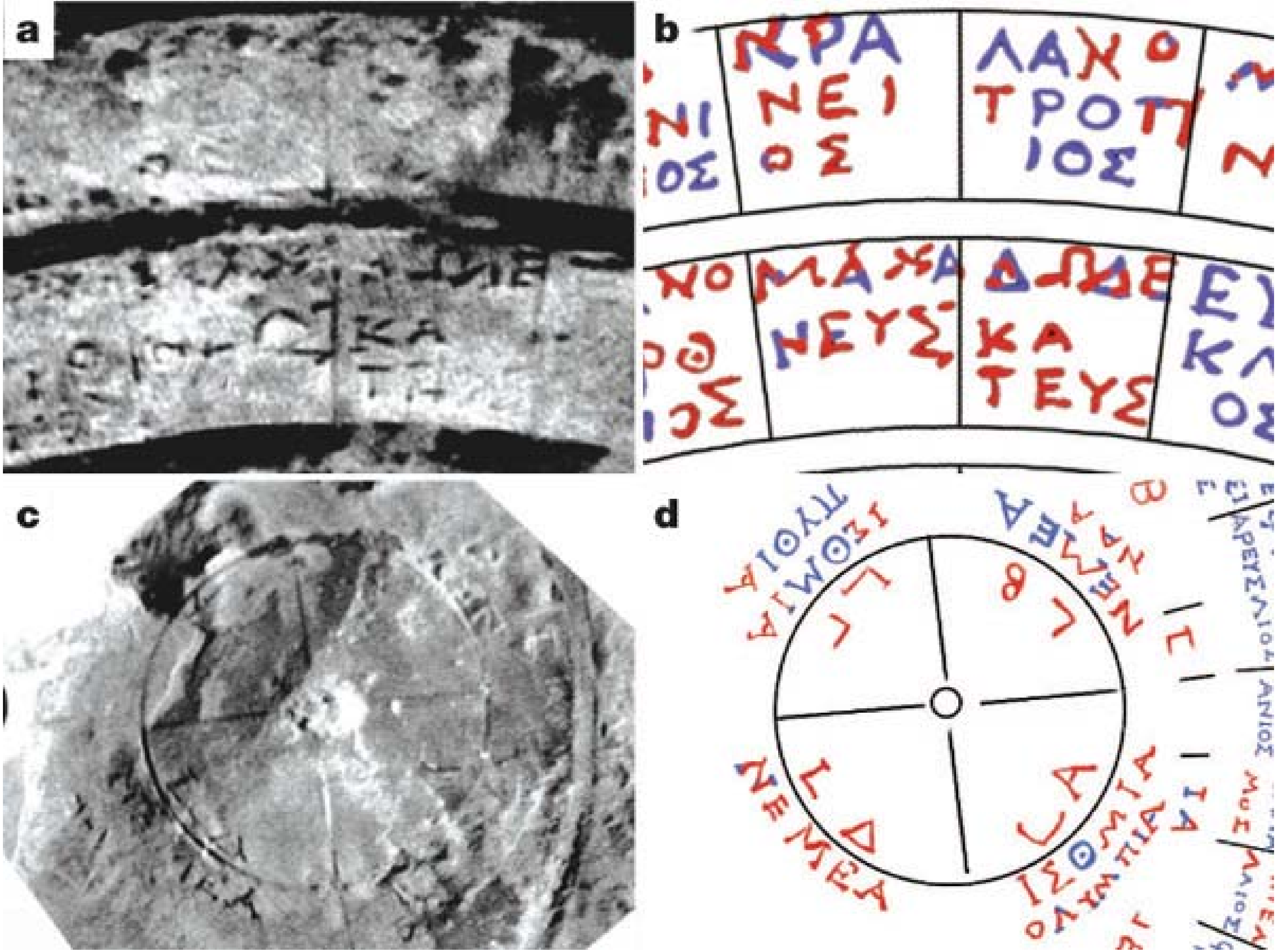
©2005 Antikythera Mechanism Research Project / National Archaeological Museum in Athens



©2005 Antikythera Mechanism Research Project, X-ray data by X-Tek Systems Ltd.

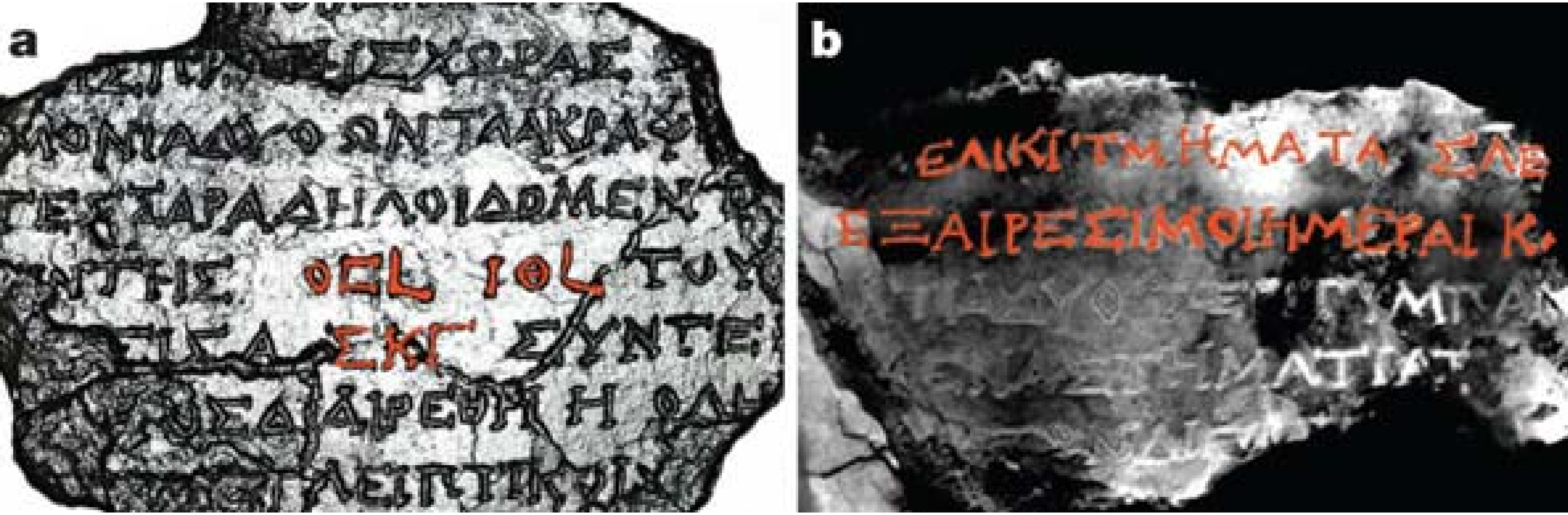
©2005 Tony Freeth

©2005 Antikythera Mechanism Research Project, digital imaging by Hewlett-Packard Inc.



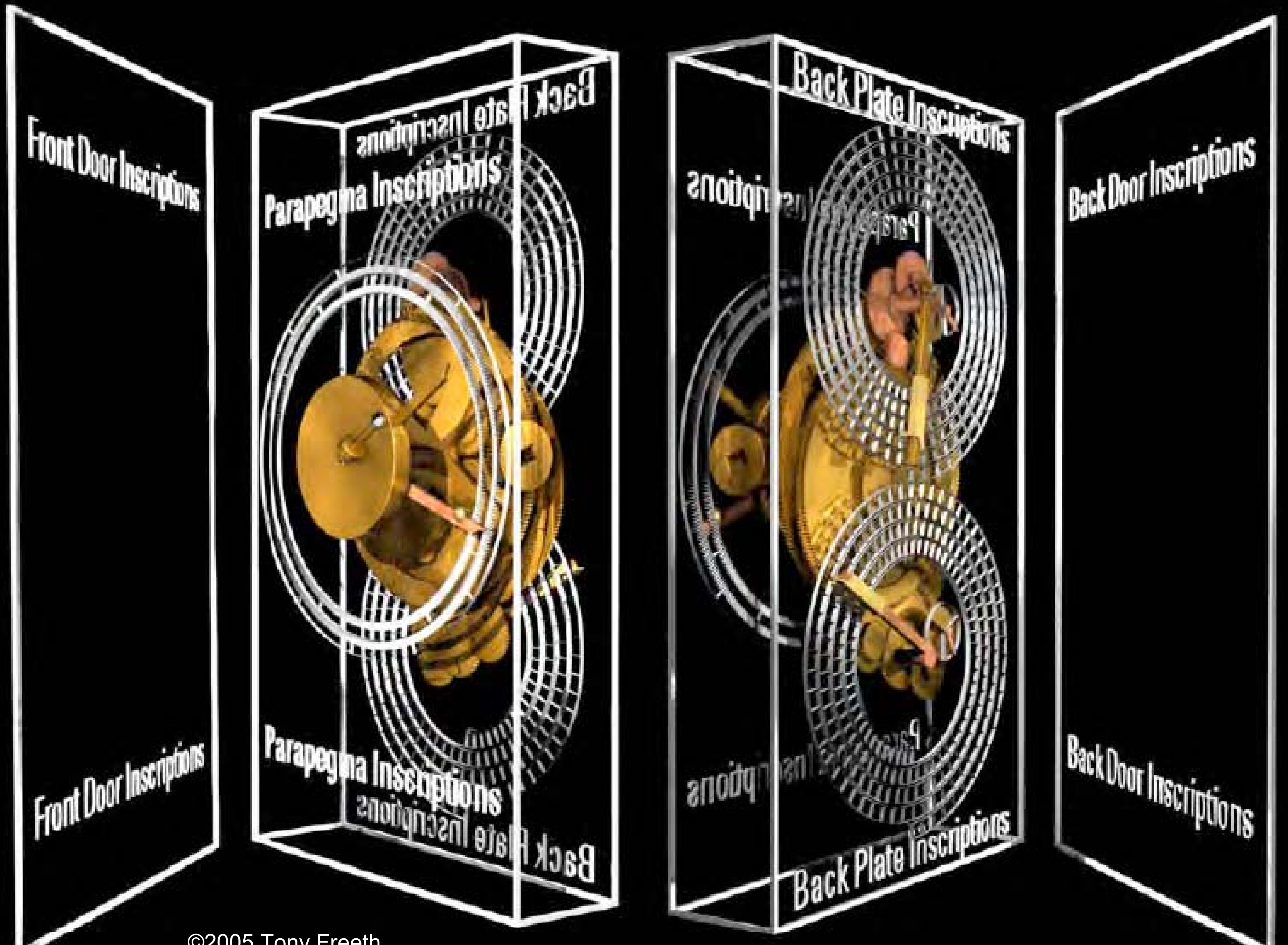
T Freeth *et al.* *Nature* **454**, 614-617 (2008) doi:10.1038/nature07130

nature

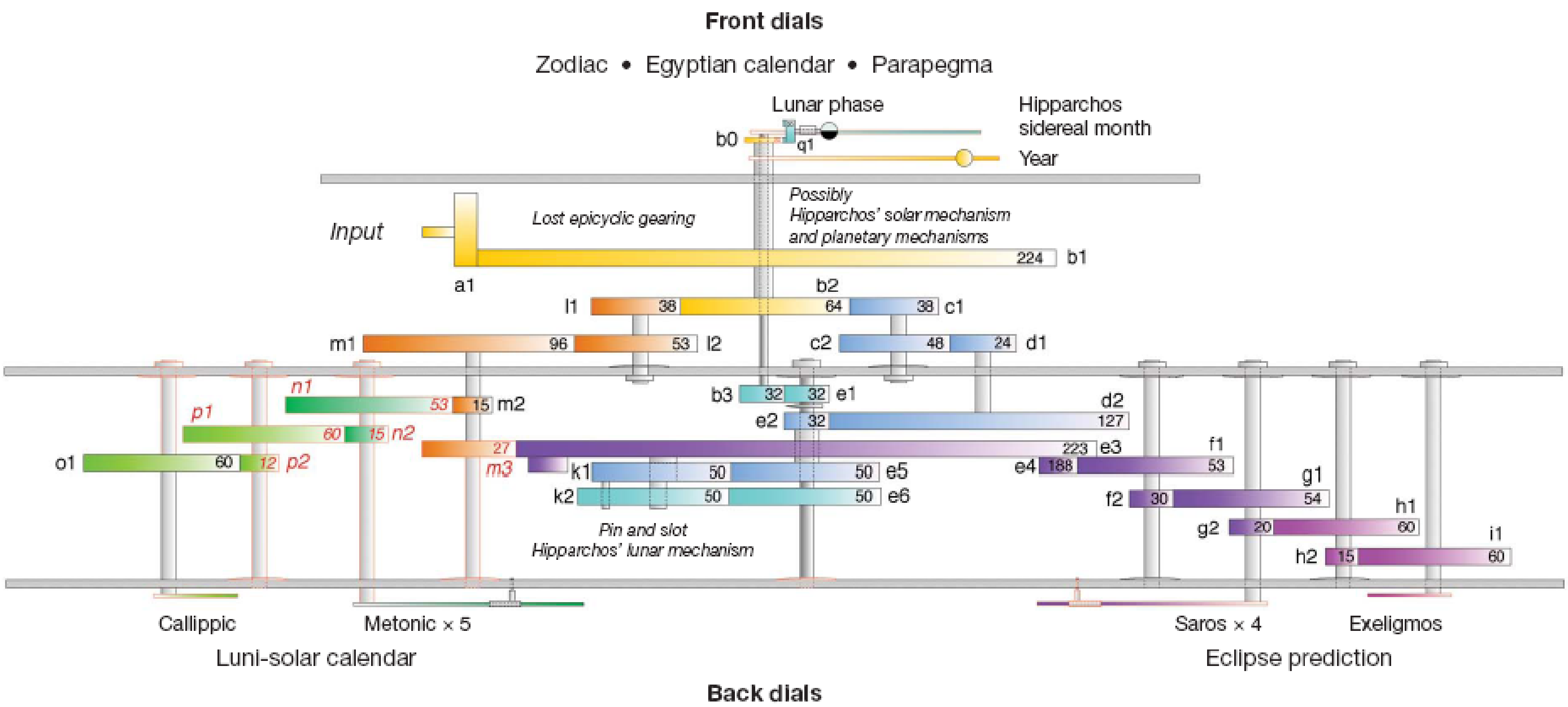


T Freeth *et al.* *Nature* **454**, 614-617 (2008) doi:10.1038/nature07130

nature

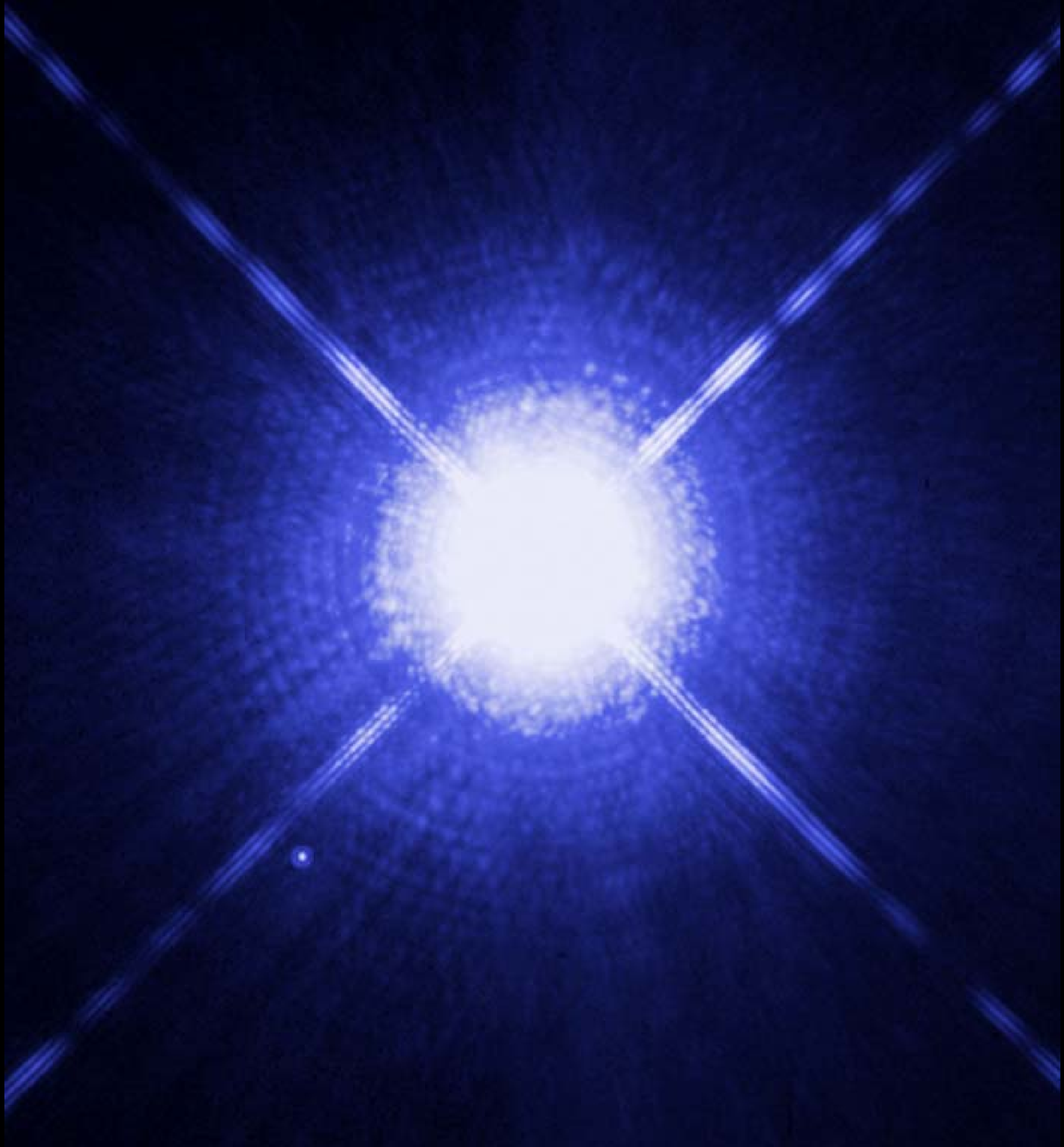


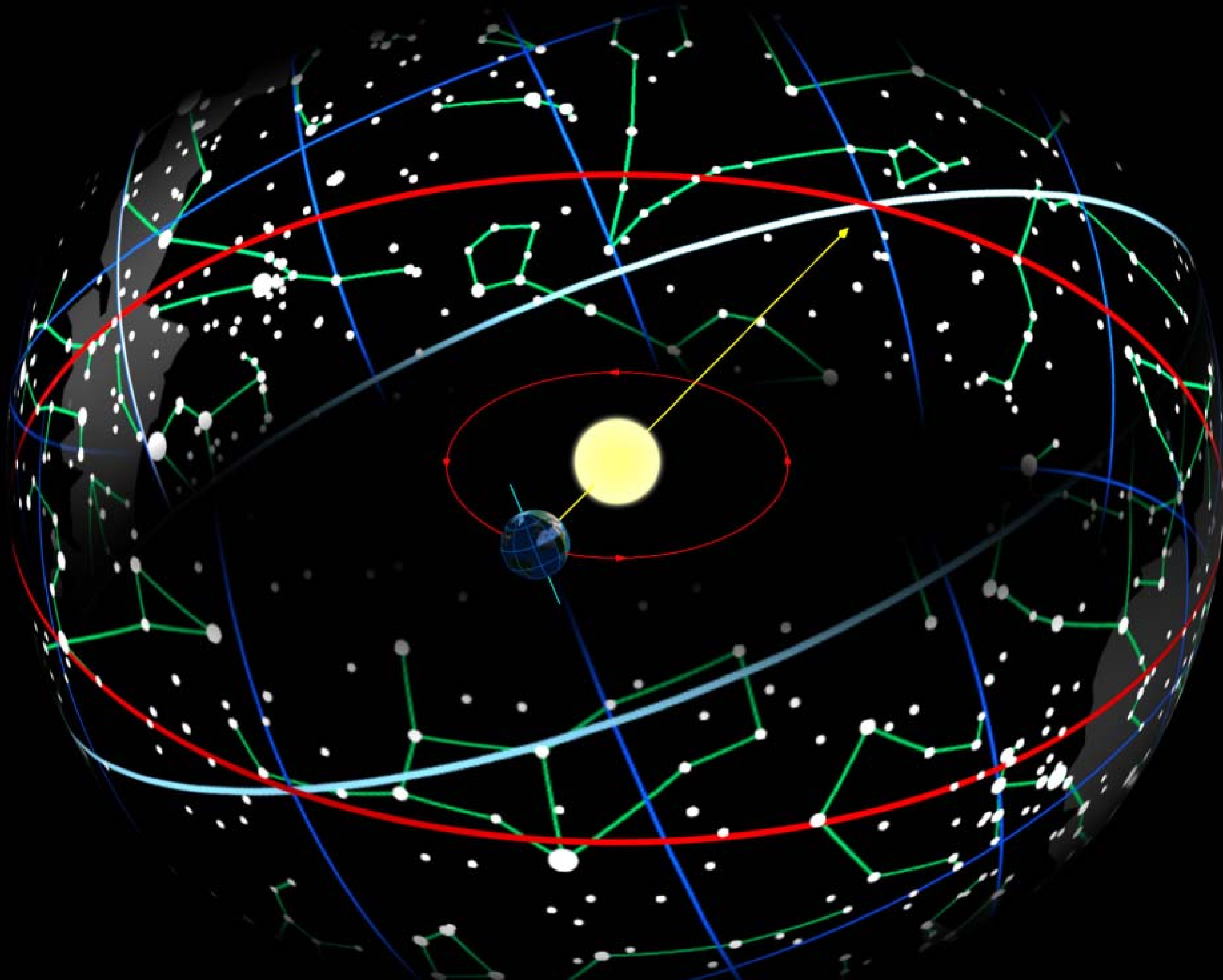
©2005 Tony Freeth



T Freeth *et al.* *Nature* **444**, 587-591 (2006) doi:10.1038/nature05357

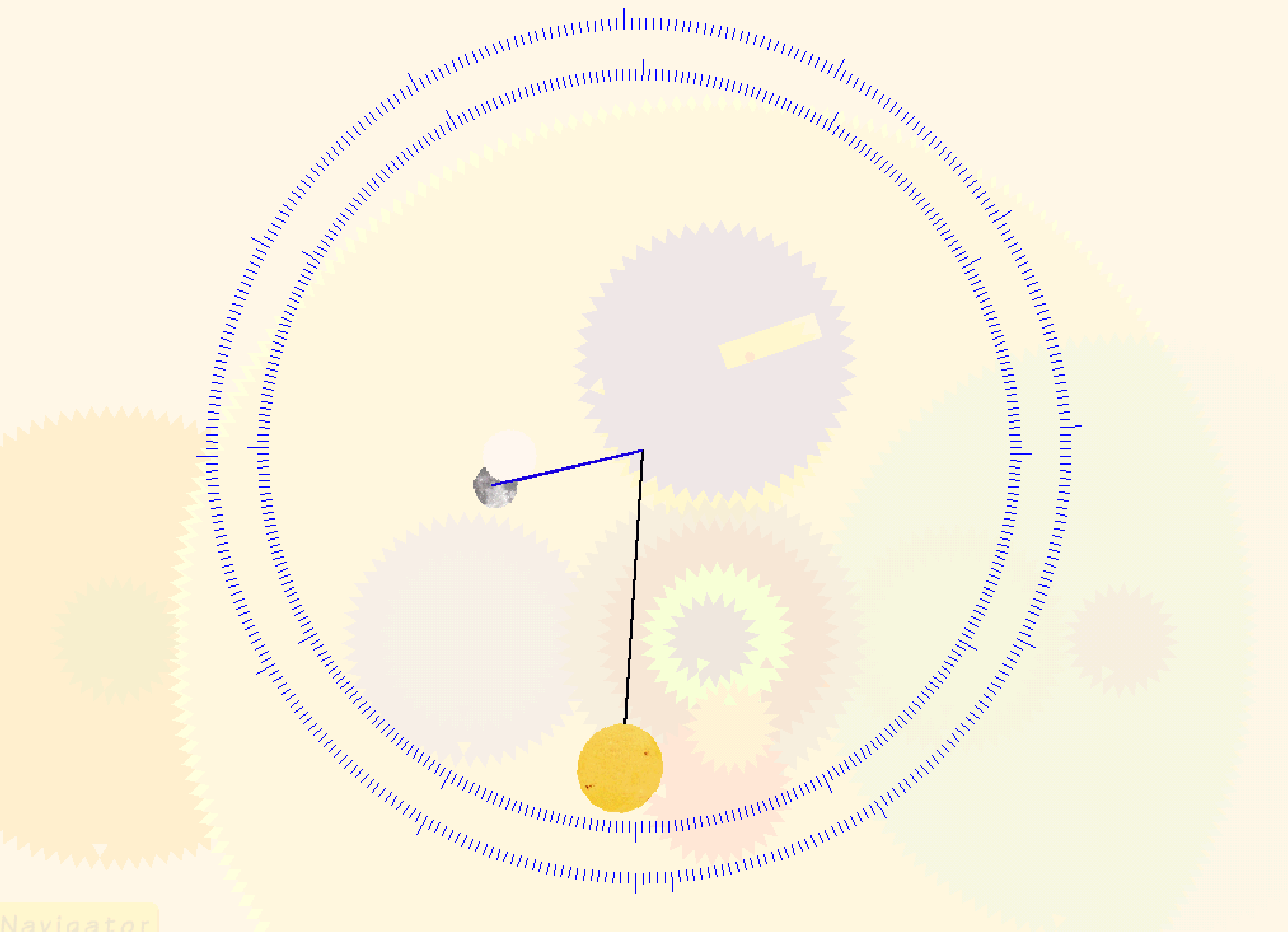
Functionality

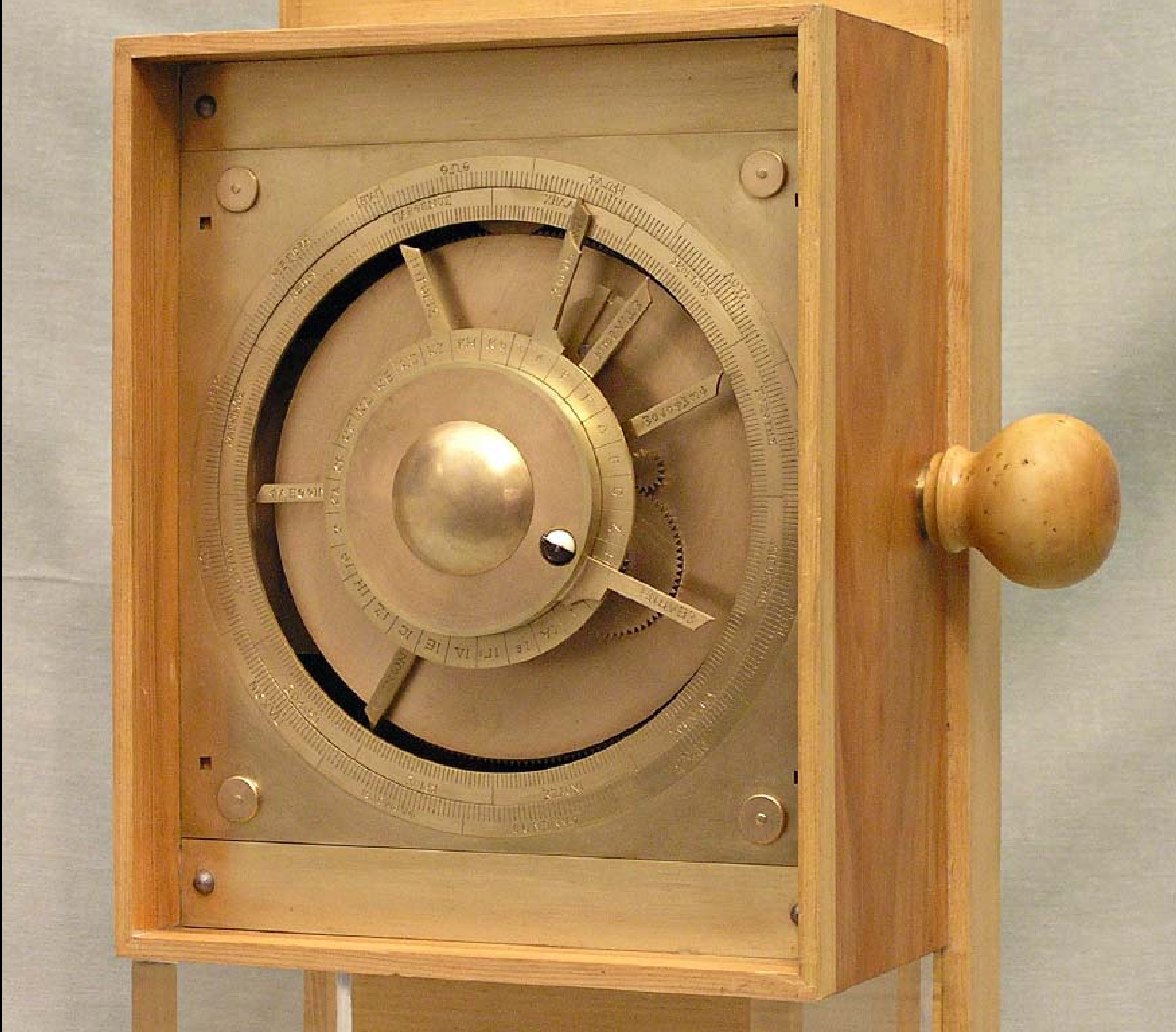




```
N = 360 * days / 365.2422;                              /* sec 42 #3 */
adj360(&N);
Msol = N + EPSILONg - RHOg;                             /* sec 42 #4 */
adj360(&Msol);
Ec = 360 / PI * ECCEN * sin(dtor(Msol));                /* sec 42 #5 */
LambdaSol = N + Ec + EPSILONg;                          /* sec 42 #6 */
adj360(&LambdaSol);
l = 13.1763966 * days + lzero;                          /* sec 61 #4 */
adj360(&l);
Mm = l - (0.1114041 * days) - Pzero;                    /* sec 61 #5 */
adj360(&Mm);
Nm = Nzero - (0.0529539 * days);                        /* sec 61 #6 */
adj360(&Nm);
Ev = 1.2739 * sin(dtor(2*(l - LambdaSol) - Mm));        /* sec 61 #7 */
Ac = 0.1858 * sin(dtor(Msol));                          /* sec 61 #8 */
A3 = 0.37 * sin(dtor(Msol));
Mmprime = Mm + Ev - Ac - A3;                            /* sec 61 #9 */
Ec = 6.2886 * sin(dtor(Mmprime));                       /* sec 61 #10 */
A4 = 0.214 * sin(dtor(2 * Mmprime));                    /* sec 61 #11 */
lprime = l + Ev + Ec - Ac + A4;                         /* sec 61 #12 */
V = 0.6583 * sin(dtor(2 * (lprime - LambdaSol)));       /* sec 61 #13 */
ldprime = lprime + V;                                   /* sec 61 #14 */
D = ldprime - LambdaSol;                                /* sec 63 #2 */
return(50 * (1 - cos(dtor(D))));                        /* sec 63 #3 */
```

/* You are not expected to understand this */

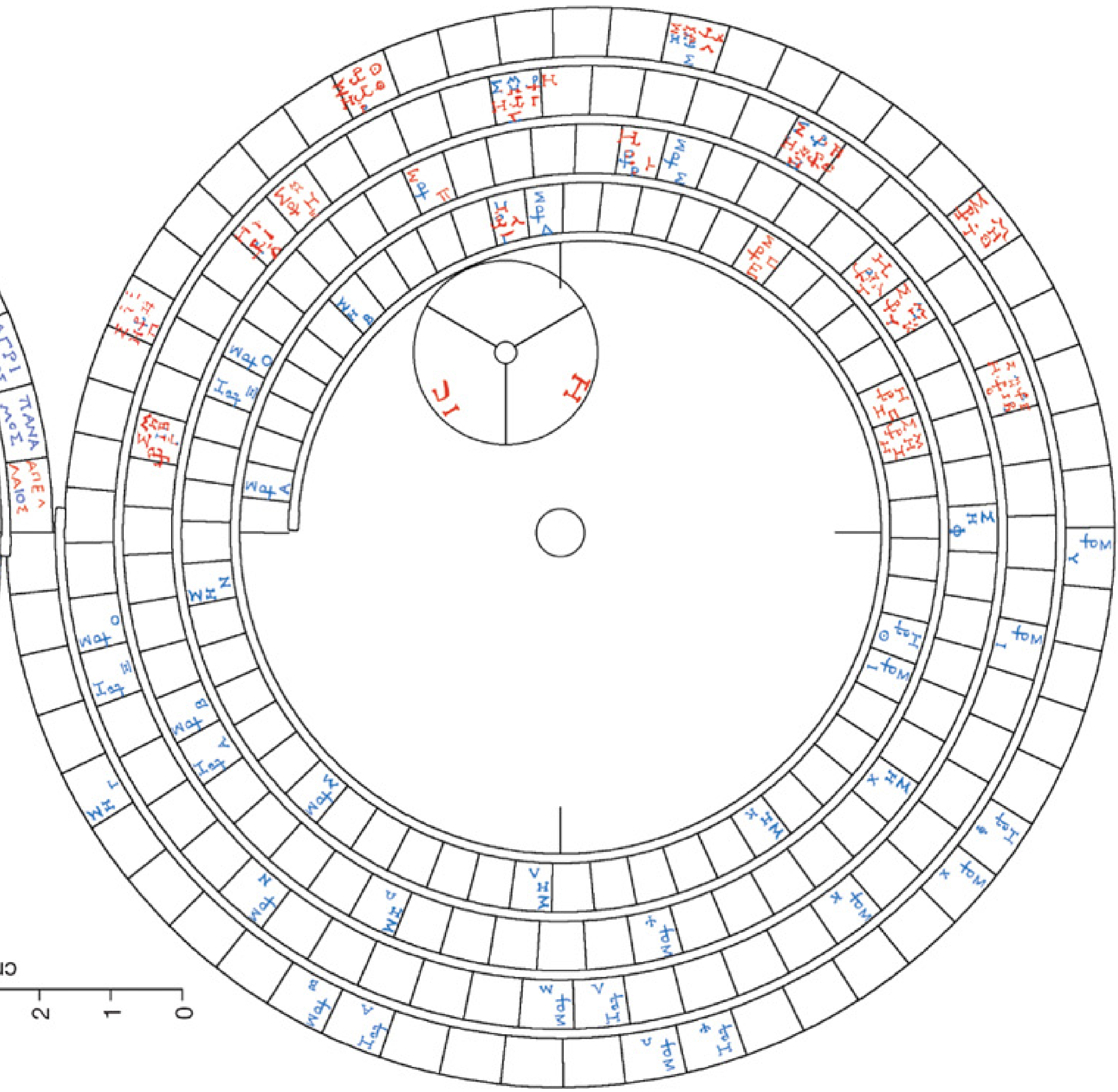

Navigator



Wright, M. T. Antiquar. Horol. 29, 319–329 (2006).

T Freeth *et al.* *Nature* **454**, 614-617 (2008) doi:10.1038/nature07130

nature



Sine/Cosine Look-Up Table v5.0

DS275 April 28, 2005 Product Specification

Features

- Drop-in module for Virtex™, Virtex-E, and Virtex-II, Virtex-II Pro, Virtex-4, Spartan™-II, Spartan-IIE, Spartan-3, and Spartan-3E FPGAs
- User specified option for table value storage in Distributed/Block Memory
- Supports THETA input widths of 3 to 10 bits for Distributed ROM and 3 to 16 bits for Block ROM
- Supports output Sine/Cosine widths of 4 to 32 bits
- Supports negative Sine/Cosine outputs

Functional Description

The Sine/Cosine module accepts an unsigned input value THETA and produces two's complement outputs of SINE (THETA) and/or COSINE (THETA). The user controls the input THETA width and output SINE and /or COSINE width values.

Equation 1 defines the relationship between the integer input angle THETA supplied to the core (refer to Figure 1) and the actual radian angle Θ

$$\theta = \text{THETA}\frac{2\Pi}{2^{\text{THETA\_WIDTH}}}\text{radians} \qquad \text{Eq. 1}$$

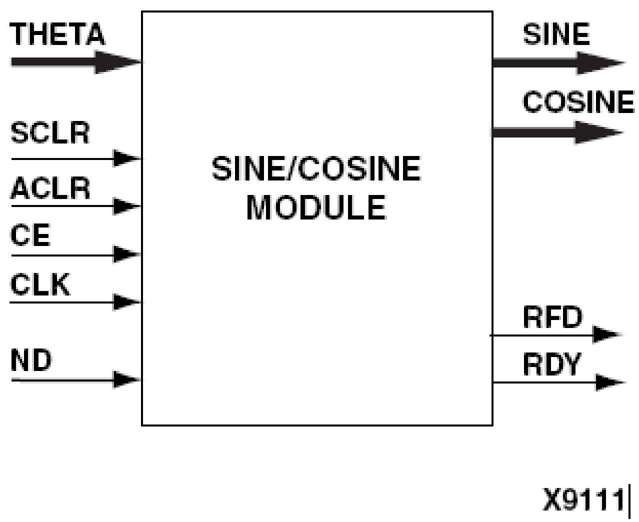
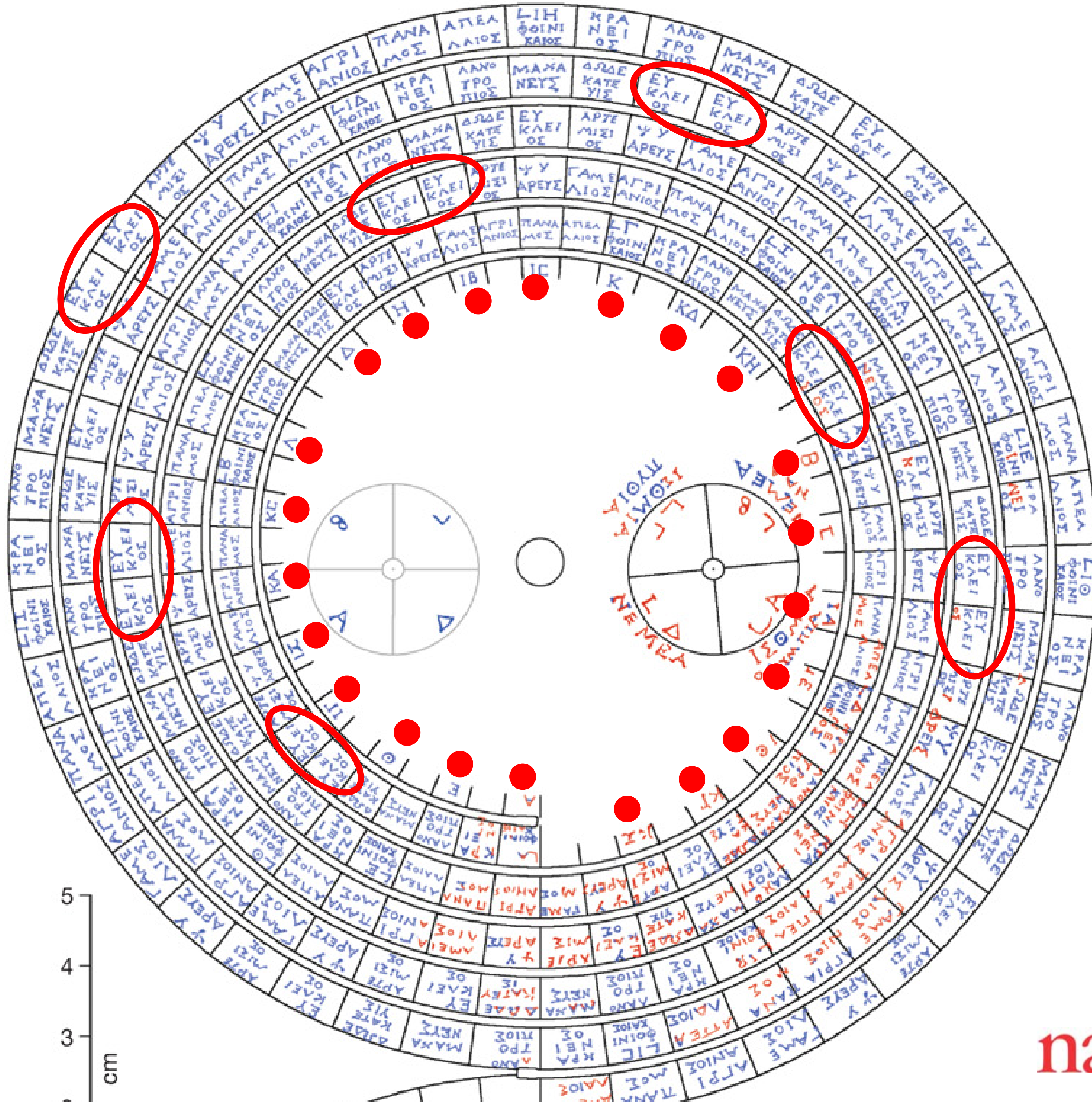


Figure 1: **Core Schematic Symbol**

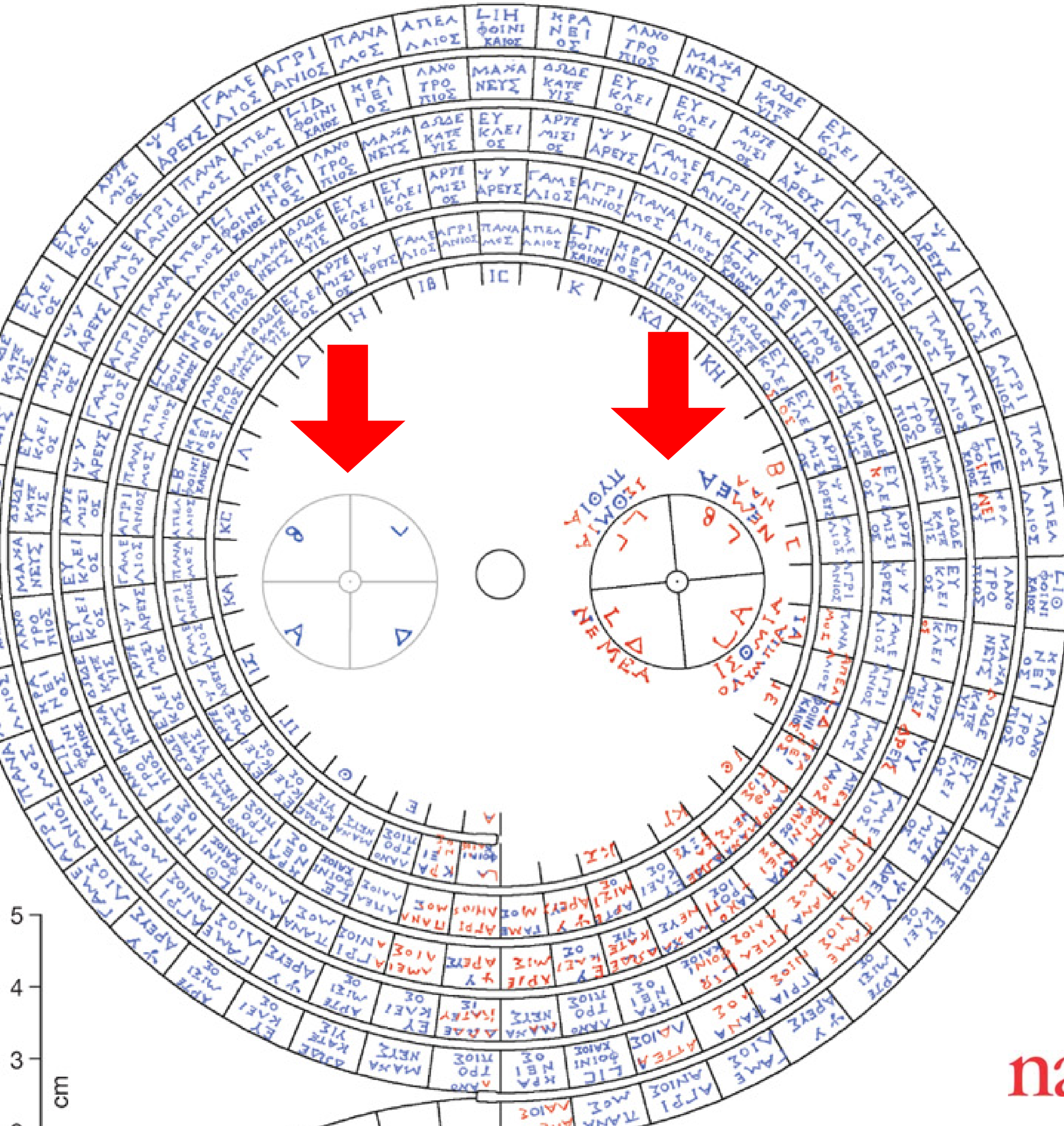

ΗΛΙΟΤΡΟΠΙΟ ΤΟΥ ΜΕΤΟΝΟΣ
METON´S SOLAR CLOCK

19	tropical years
235	synodic months
6939	days

Complications



T Freeth *et al.* *Nature* **454**, 614-617 (2008) doi:10.1038/nature07130

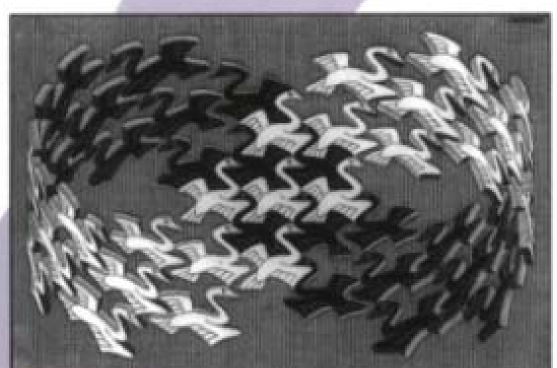


T Freeth *et al.* *Nature* **454**, 614-617 (2008) doi:10.1038/nature07130

Design Patterns

Elements of Reusable Object-Oriented Software

Erich Gamma
Richard Helm
Ralph Johnson
John Vlissides



Cover art © 1994 M.C. Escher / Cordon Art - Baarn - Holland. All rights reserved.

Foreword by Grady Booch

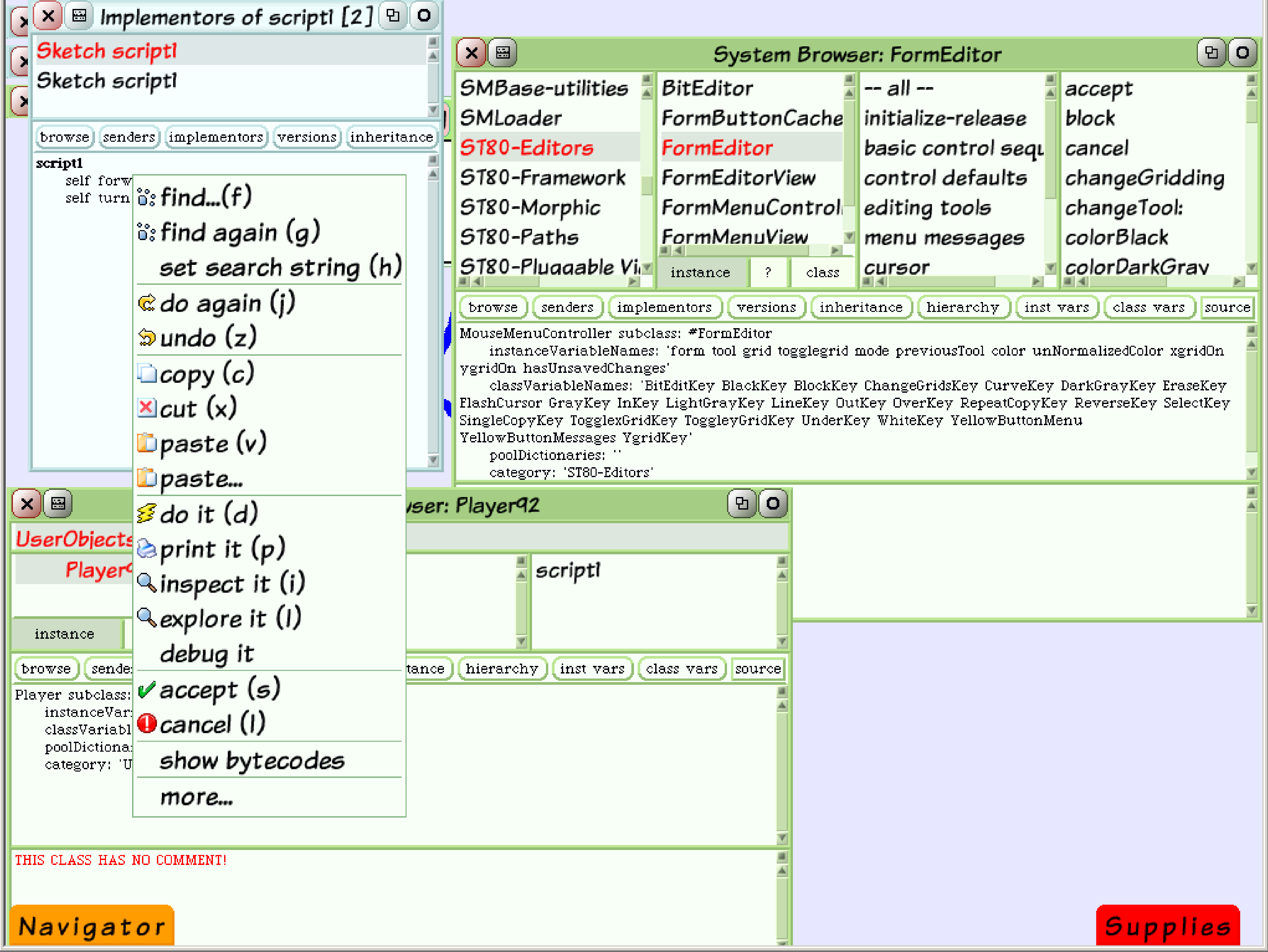
ADDISON-WESLEY PROFESSIONAL COMPUTING SERIES

Operation

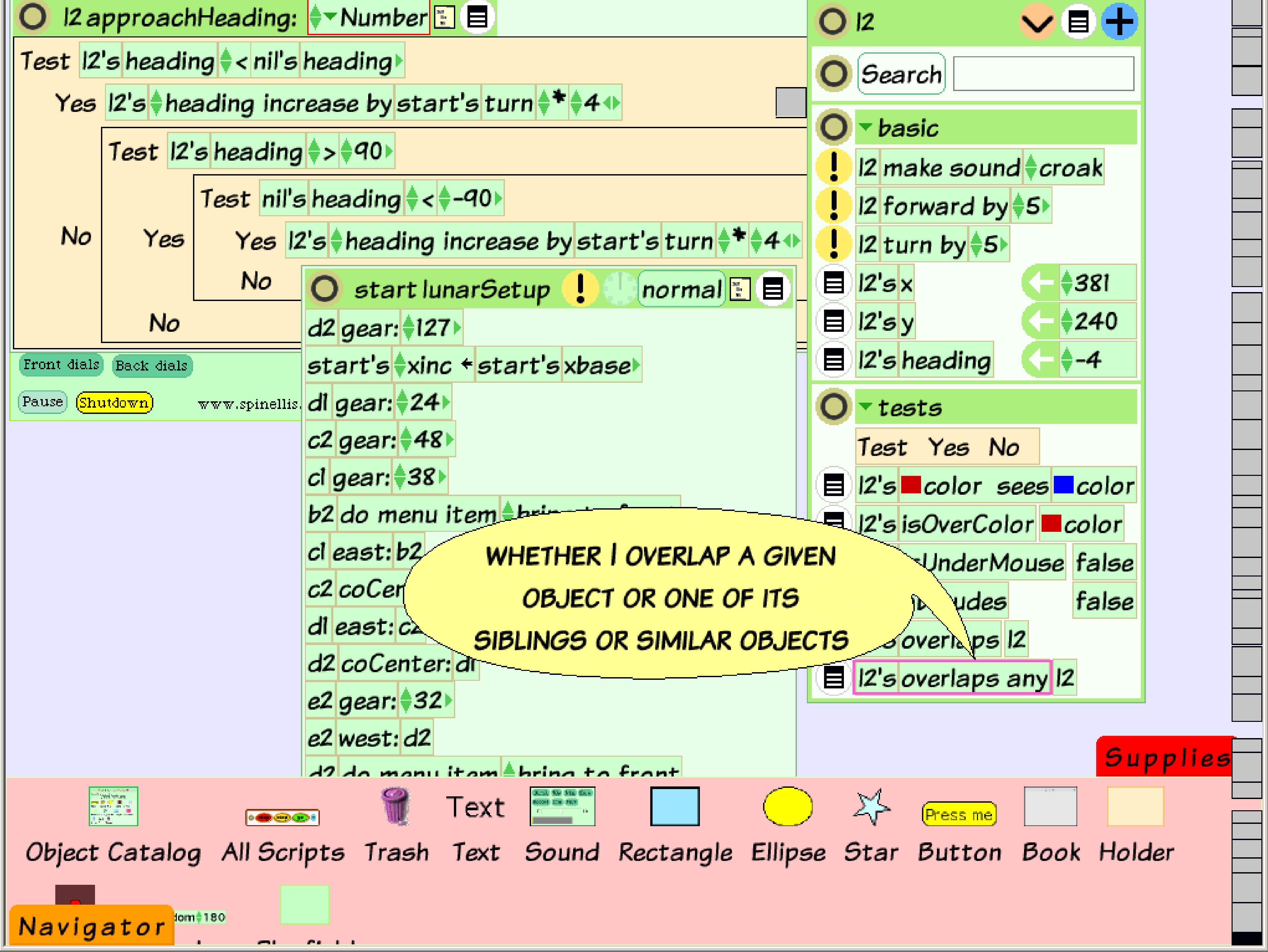
Simulation

Emulation

¿ Squeak ?

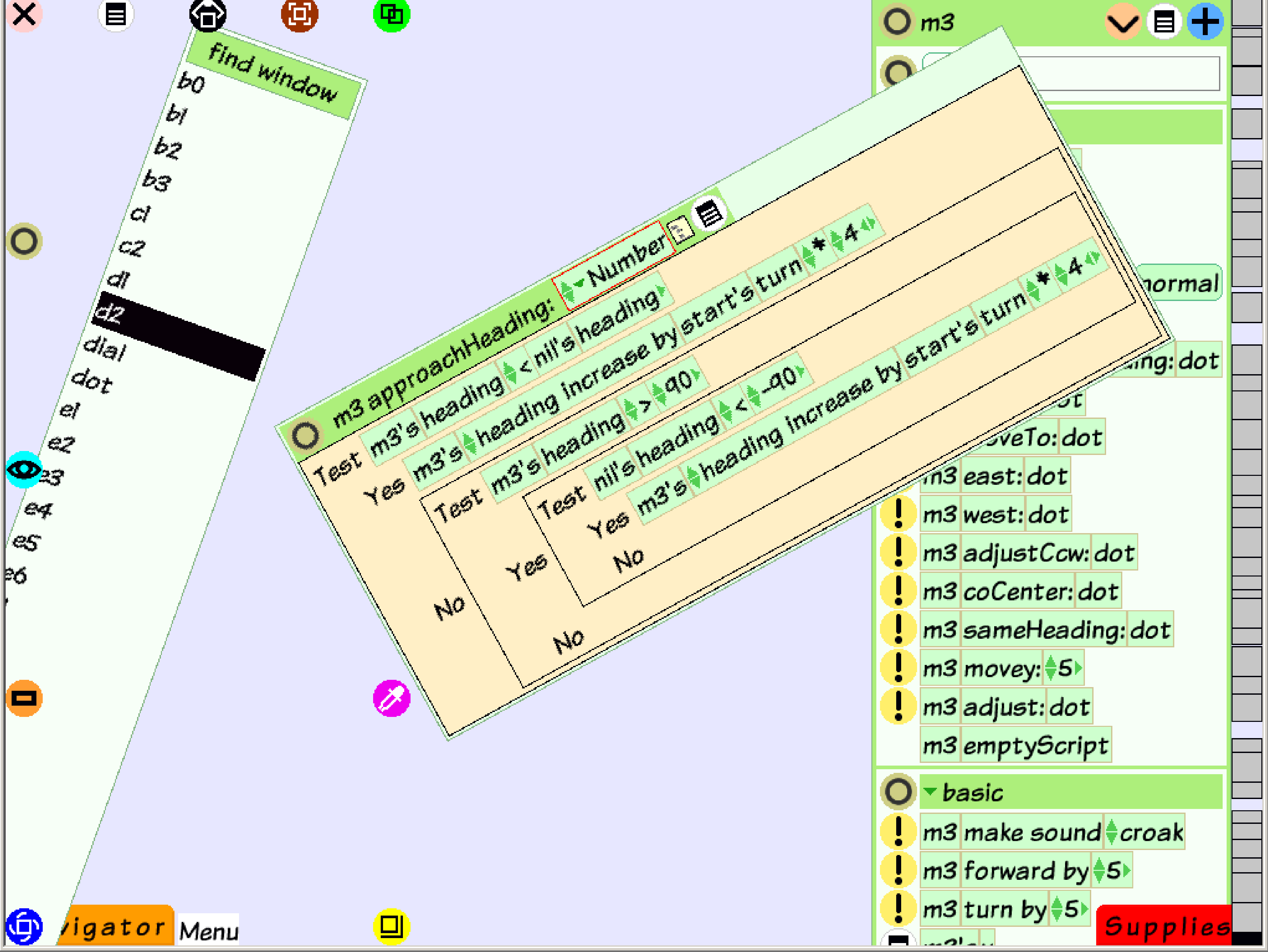

Implementors of script1 [2]
Sketch script1
Sketch script1
browse senders implementors versions inheritance
script1
self forw
self turn
find...(f)
find again (g)
set search string (h)
do again (j)
undo (z)
copy (c)
cut (x)
paste (v)
paste...
do it (d)
print it (p)
inspect it (i)
explore it (I)
debug it
accept (s)
cancel (l)
show bytecodes
more...
System Browser: FormEditor
SMBase-utilities
SMLoader
ST80-Editors
ST80-Framework
ST80-Morphic
ST80-Paths
BitEditor
FormButtonCache
FormEditor
FormEditorView
-- all --
initialize-release
control defaults
editing tools
menu messages
cursor
accept
block
cancel
changeGridding
changeTool:
colorBlack
instance
?
class
browse senders implementors versions inheritance hierarchy inst vars class vars source
MouseMenuController subclass: #FormEditor
instanceVariableNames: 'form tool grid togglegrid mode previousTool color unNormalizedColor xgridOn ygridOn hasUnsavedChanges'
classVariableNames: 'BitEditKey BlackKey BlockKey ChangeGridsKey CurveKey DarkGrayKey EraseKey FlashCursor GrayKey InKey LightGrayKey LineKey OutKey OverKey RepeatCopyKey ReverseKey SelectKey SingleCopyKey TogglexGridKey ToggleyGridKey UnderKey WhiteKey YellowButtonMenu YellowButtonMessages YgridKey'
poolDictionaries: ''
category: 'ST80-Editors'
ser: Player92
script1
instance
browse
hierarchy inst vars class vars source
Player subclass:
THIS CLASS HAS NO COMMENT!
Navigator
Supplies

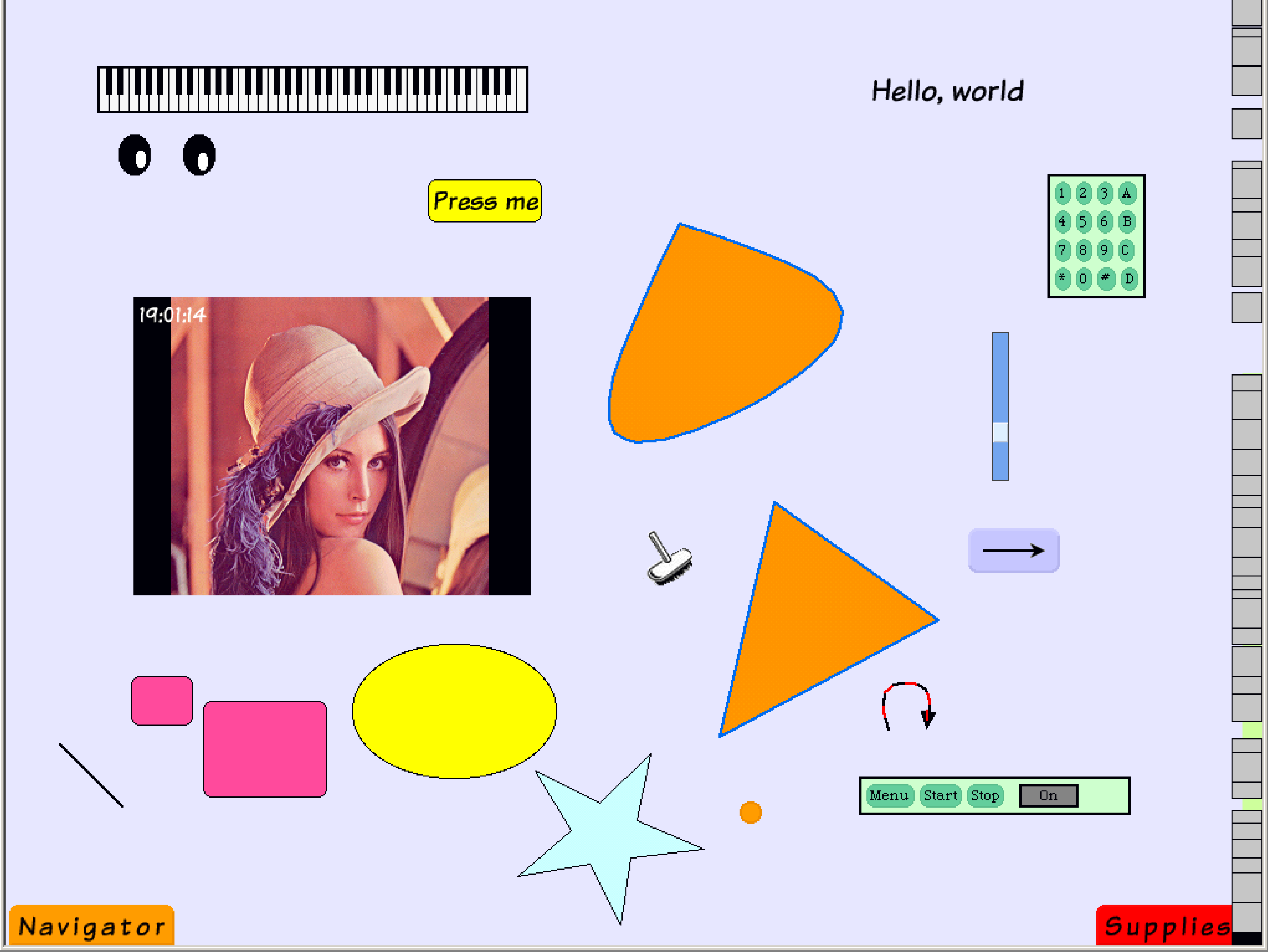
¿Squeak Etoys?

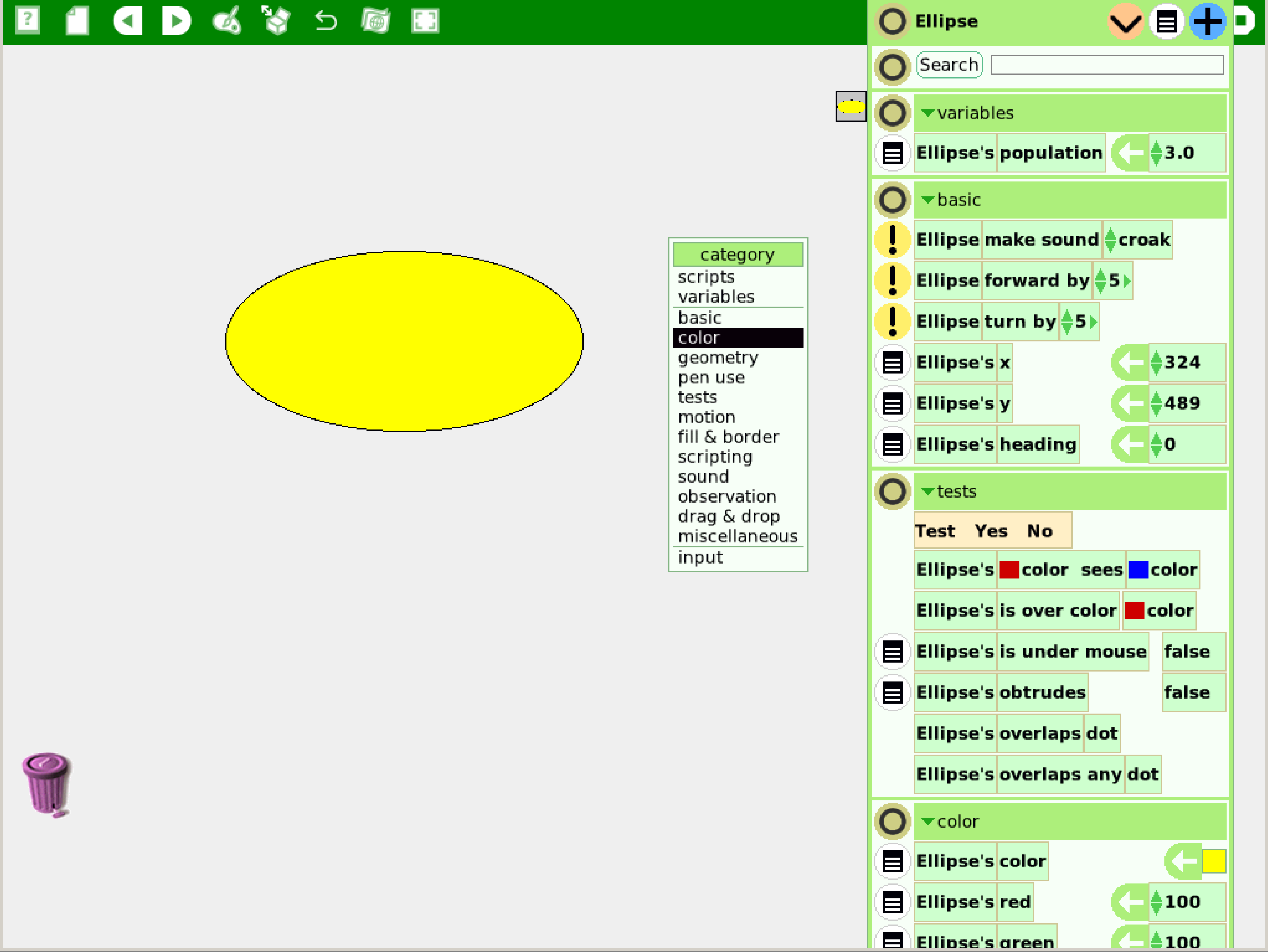


l2 approachHeading: Number
Test l2's heading < nil's heading
Yes l2's heading increase by start's turn * 4
Test l2's heading > 90
Test nil's heading < -90
Yes l2's heading increase by start's turn * 4
No
Yes
No
No
Front dials
Back dials
Pause
Shutdown
www.spinellis.
start lunarSetup
normal
d2 gear: 127
start's xinc ← start's xbase
d1 gear: 24
c2 gear: 48
c1 gear: 38
b2 do menu item
c1 east: b2
c2 coCen
d1 east: c2
d2 coCenter: d1
e2 gear: 32
e2 west: d2
d2 do menu item bring to front
WHETHER I OVERLAP A GIVEN OBJECT OR ONE OF ITS SIBLINGS OR SIMILAR OBJECTS
l2
Search
basic
l2 make sound croak
l2 forward by 5
l2 turn by 5
l2's x 381
l2's y 240
l2's heading -4
tests
Test Yes No
l2's color sees color
l2's isOverColor color
UnderMouse false
udes false
overlaps l2
l2's overlaps any l2
Supplies
Object Catalog
All Scripts
Trash
Text
Sound
Rectangle
Ellipse
Star
Press me
Button
Book
Holder
Navigator


Navigator
Supplier


find window
b0
b1
b2
b3
c1
c2
d1
d2
dial
dot
e1
e2
e3
e4
e5
e6
m3 approachHeading: Number
Test m3's heading < nil's heading
Yes m3's heading increase by start's turn * 4
Test m3's heading > 90
Test nil's heading < -90
Yes m3's heading increase by start's turn * 4
No
Yes
No
No
m3
normal
m3 east: dot
m3 west: dot
m3 adjustCcw: dot
m3 coCenter: dot
m3 sameHeading: dot
m3 movey: 5
m3 adjust: dot
m3 emptyScript
basic
m3 make sound croak
m3 forward by 5
m3 turn by 5
Menu
Supplies

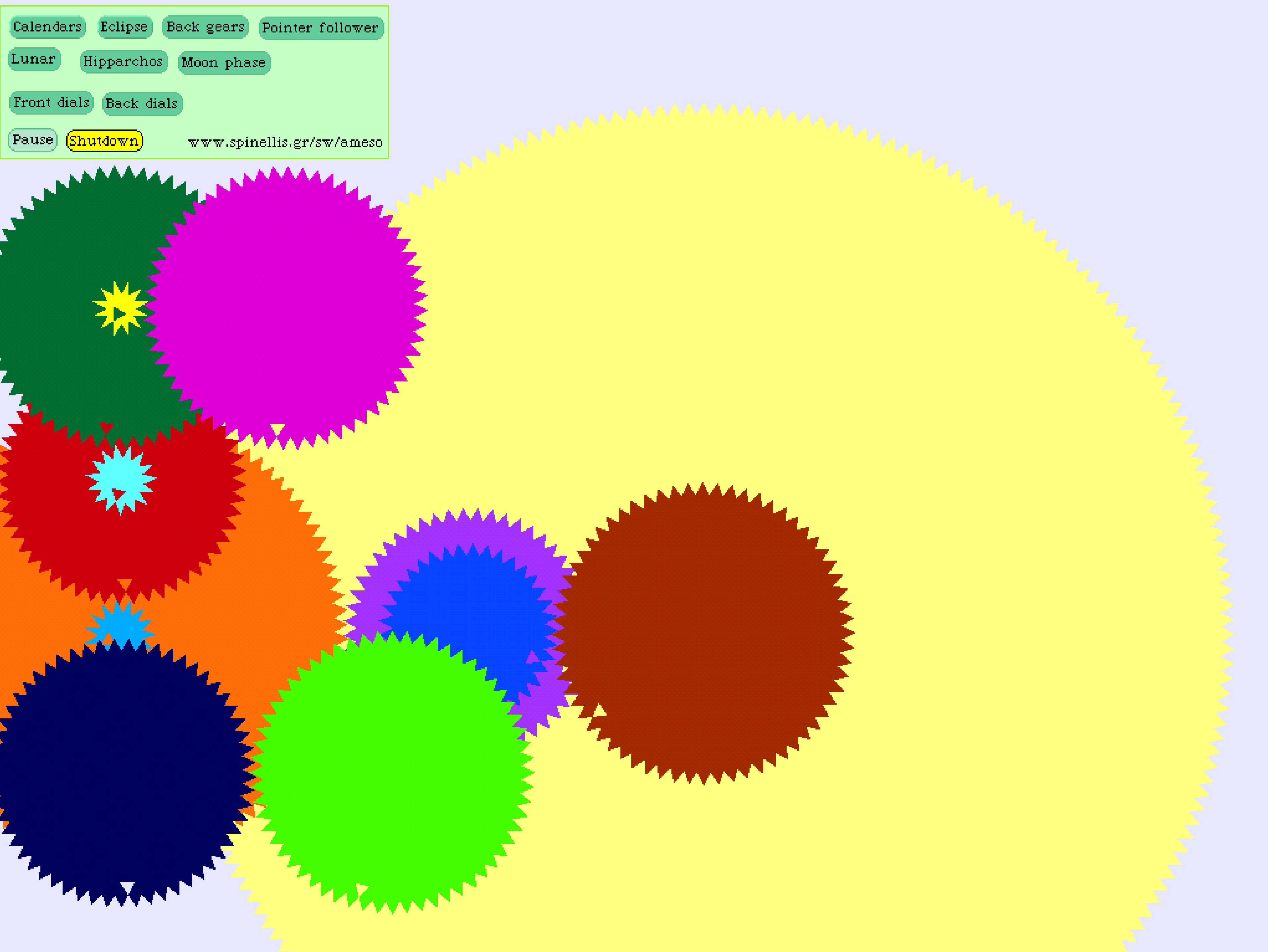

Hello, world
Press me
19:01:14
1 2 3 A
4 5 6 B
7 8 9 C
* 0 # D
Menu Start Stop On
Navigator
Supplies

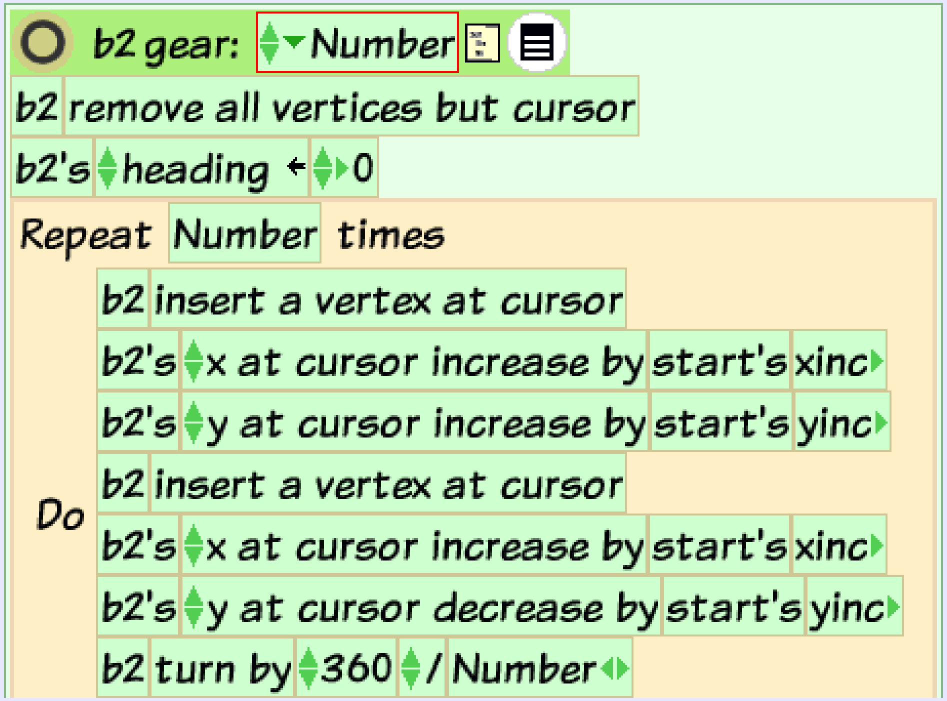

Ellipse
Search
variables
Ellipse's population 3.0
basic
Ellipse make sound croak
Ellipse forward by 5
Ellipse turn by 5
Ellipse's x 324
Ellipse's y 489
Ellipse's heading 0
tests
Test Yes No
Ellipse's color sees color
Ellipse's is over color color
Ellipse's is under mouse false
Ellipse's obtrudes false
Ellipse's overlaps dot
Ellipse's overlaps any dot
color
Ellipse's color
Ellipse's red 100
Ellipse's green 100
category
scripts
variables
basic
color
geometry
pen use
tests
motion
fill & border
scripting
sound
observation
drag & drop
miscellaneous
input

Navigator

Supplies

Etoys lacks


Calendars
Eclipse
Back gears
Pointer follower
Lunar
Hipparchos
Moon phase
Front dials
Back dials
Pause
Shutdown
www.spinellis.gr/sw/ameso


b2 gear: Number
b2 remove all vertices but cursor
b2's heading ← 0
Repeat Number times
Do
b2 insert a vertex at cursor
b2's x at cursor increase by start's xinc
b2's y at cursor increase by start's yinc
b2 insert a vertex at cursor
b2's x at cursor increase by start's xinc
b2's y at cursor decrease by start's yinc
b2 turn by 360 / Number

b2 demoGearAdd normal

b2 insert a vertex at cursor

b2's x at cursor increase by 30

b2's y at cursor increase by 30

b2 insert a vertex at cursor

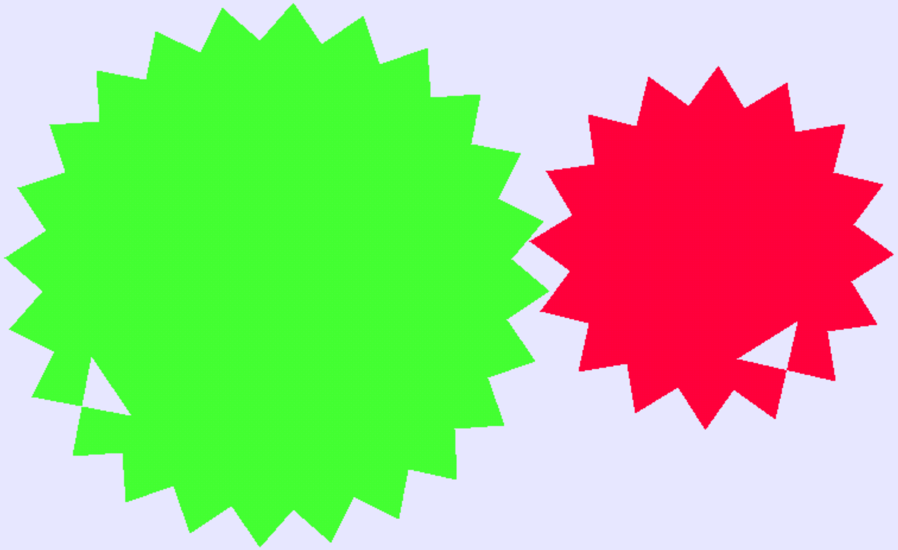
b2's x at cursor increase by 30

b2's y at cursor decrease by 30

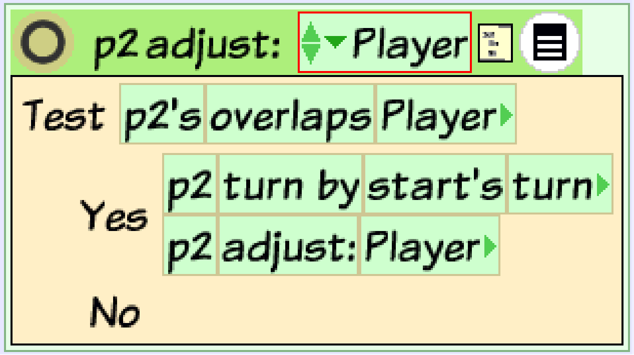
b2 turn by 30

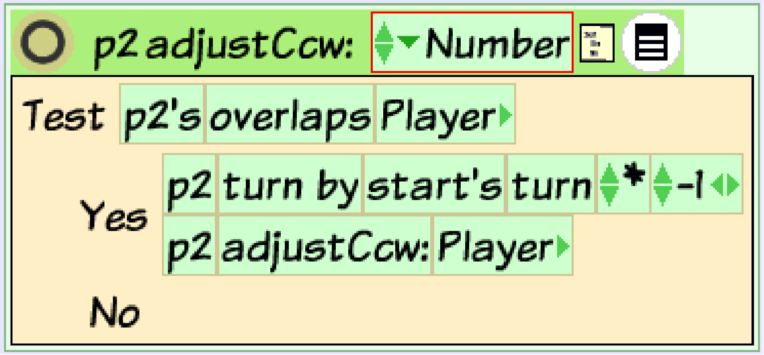
```
b1 north: Player
b1 movex: nil's x
b1 movey: nil's top + start's delta + b1's length / 2
```

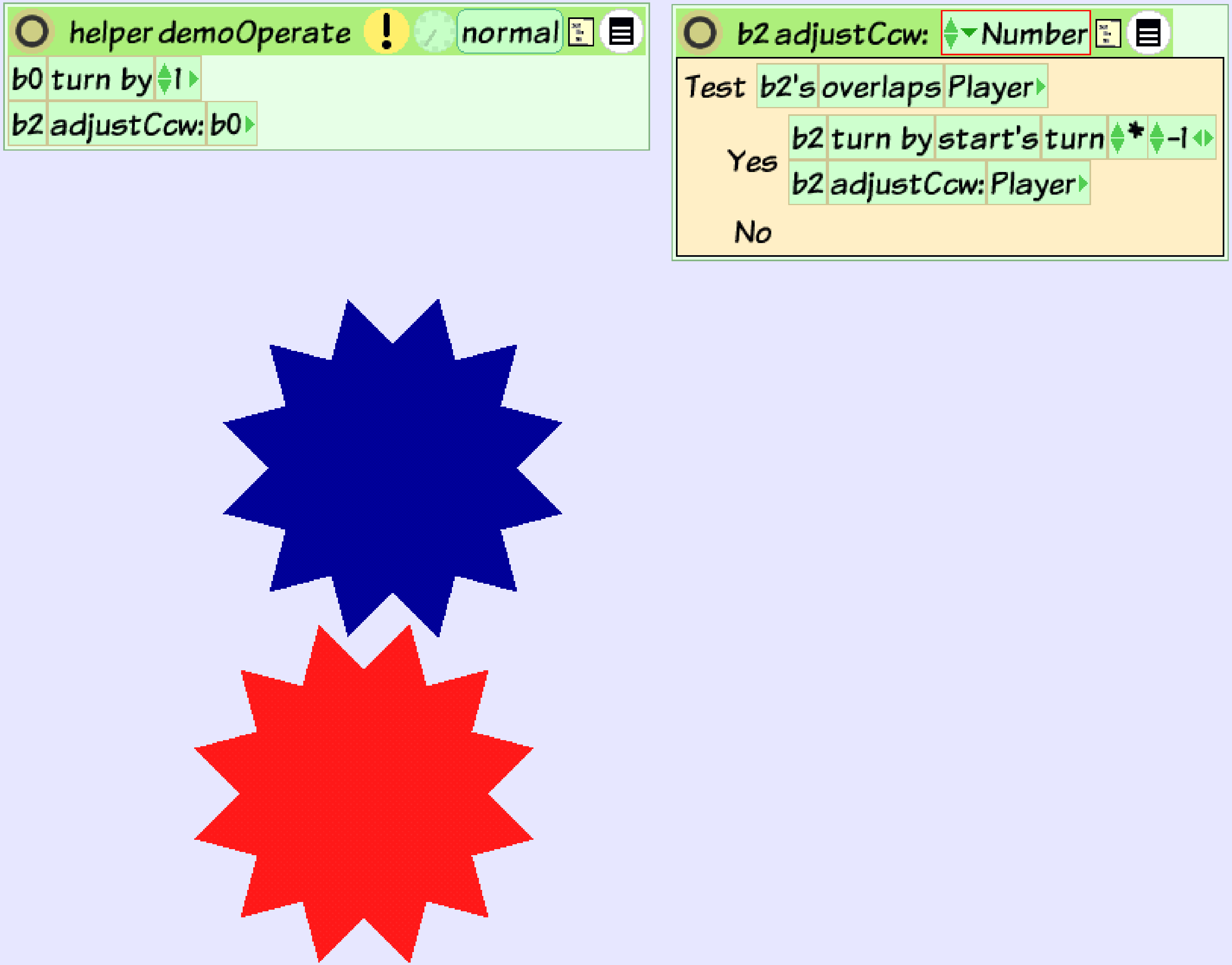
```
start luniSolarSetup normal
m1 east: l2
m1 west: l2
m2 gear: 15
m2 coCenter: m1
n1 gear: 53
n1 north: m2
n2 gear: 15
n2 coCenter: n1
p1 gear: 60
p1 north: n2
p2 gear: 12
p2 coCenter: p1
o1 gear: 60
o1 east: p2
```

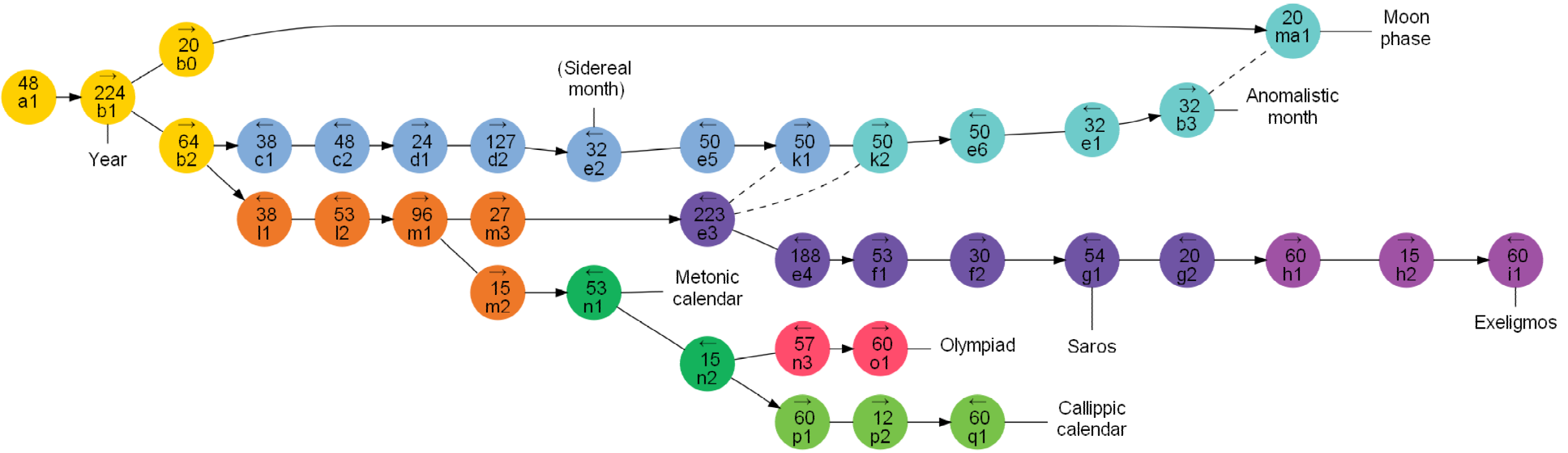



p2 sameHeading: Number
p2's heading ← nil's heading

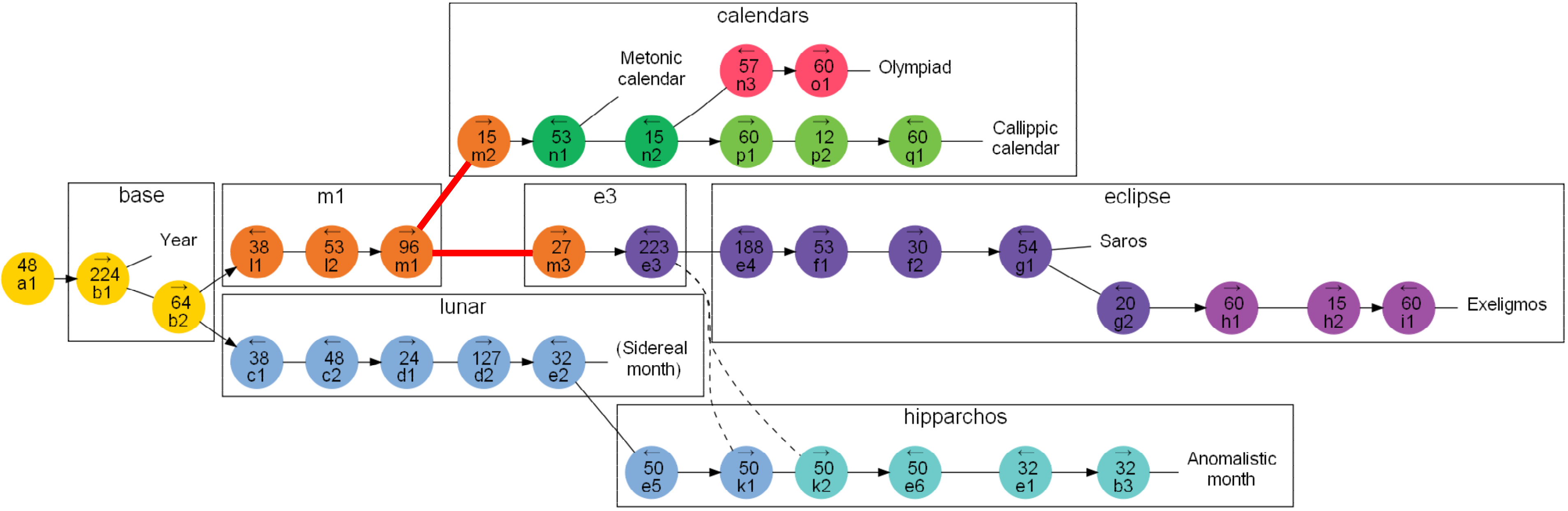

p2 adjust: Player
Test p2's overlaps Player
Yes p2 turn by start's turn
p2 adjust: Player
No


p2 adjustCcw: Number
Test p2's overlaps Player
Yes p2 turn by start's turn * -1
p2 adjustCcw: Player
No

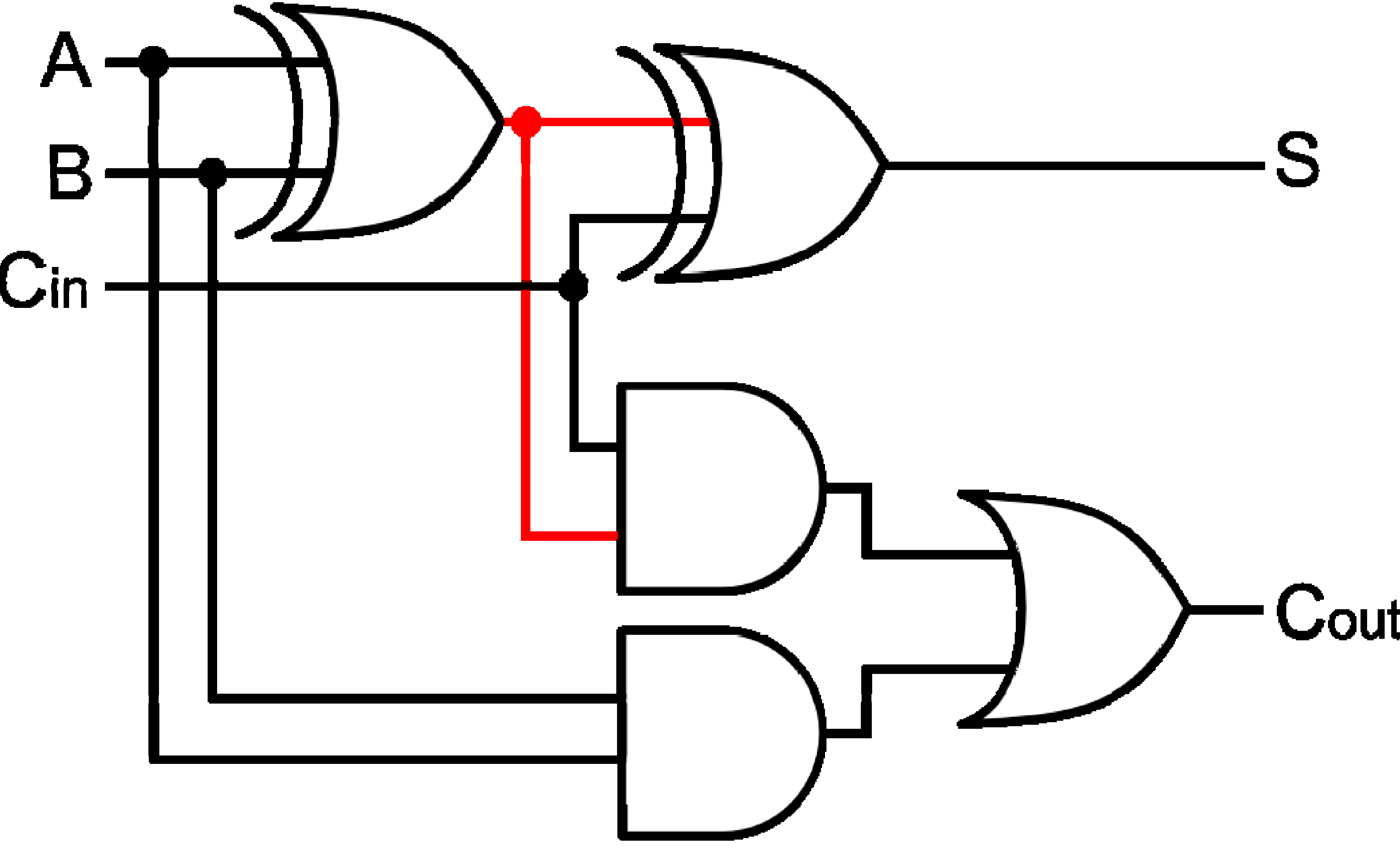

helper demoOperate
normal
b0 turn by 1
b2 adjustCcw: b0
b2 adjustCcw: Number
Test b2's overlaps Player
Yes
b2 turn by start's turn * -1
b2 adjustCcw: Player
No

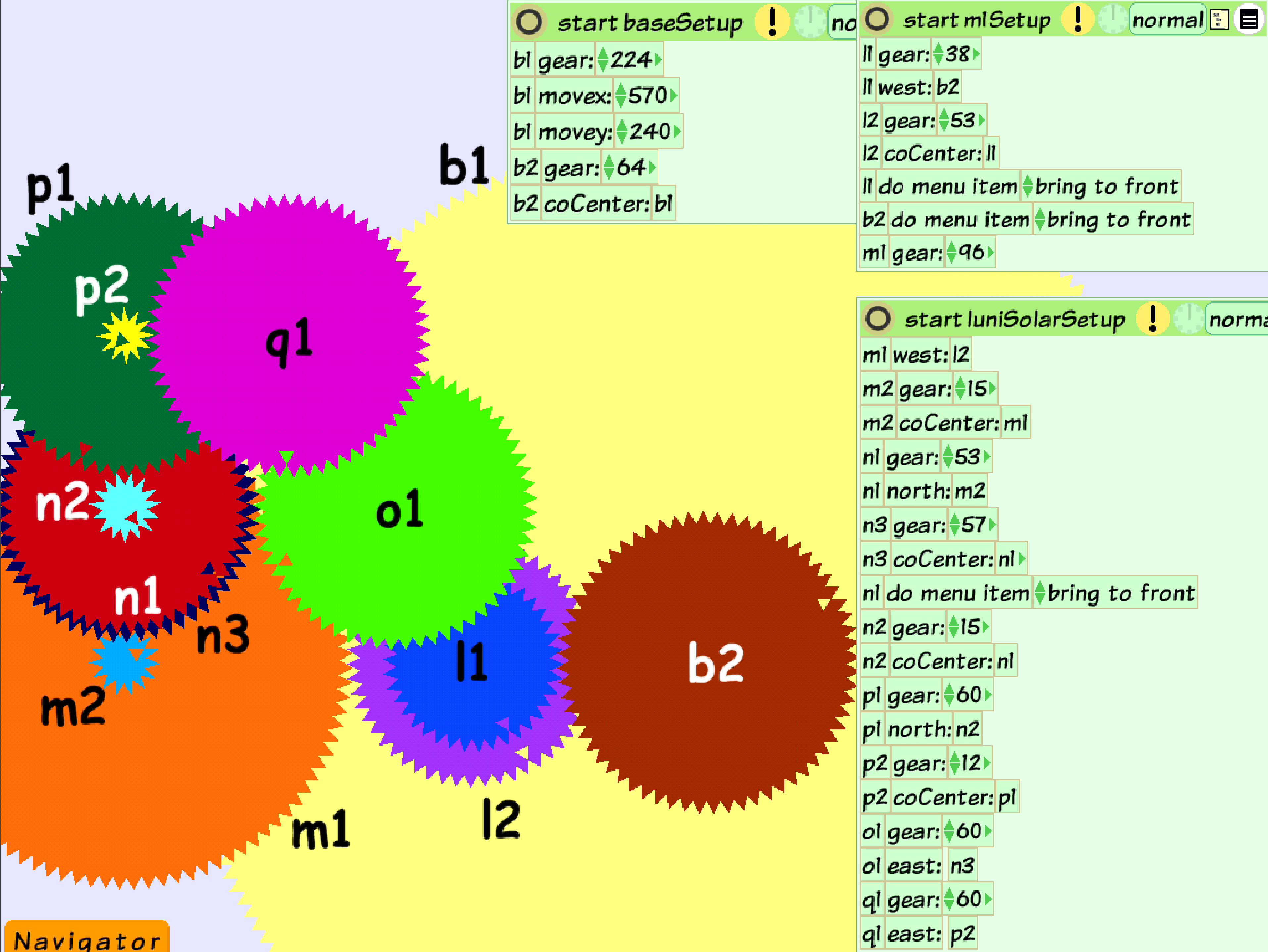


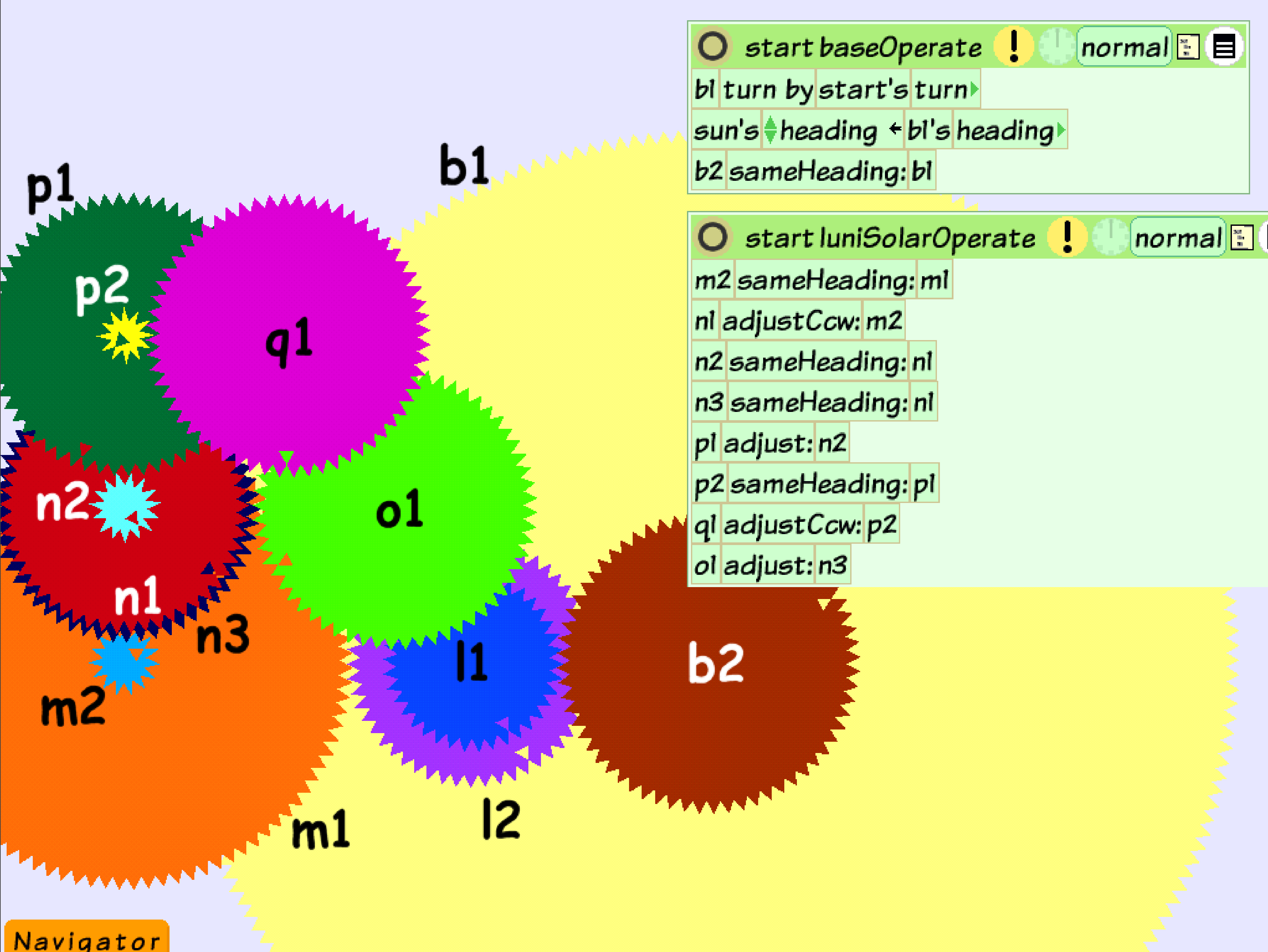
48 a1
224 b1
Year
20 b0
64 b2
38 c1
48 c2
24 d1
127 d2
(Sidereal month)
32 e2
50 e5
50 k1
50 k2
50 e6
32 e1
32 b3
Anomalistic month
20 ma1
Moon phase
38 l1
53 l2
96 m1
27 m3
223 e3
188 e4
53 f1
30 f2
54 g1
20 g2
60 h1
15 h2
60 i1
Exeligmos
Saros
15 m2
53 n1
Metonic calendar
15 n2
57 n3
60 o1
Olympiad
60 p1
12 p2
60 q1
Callippic calendar



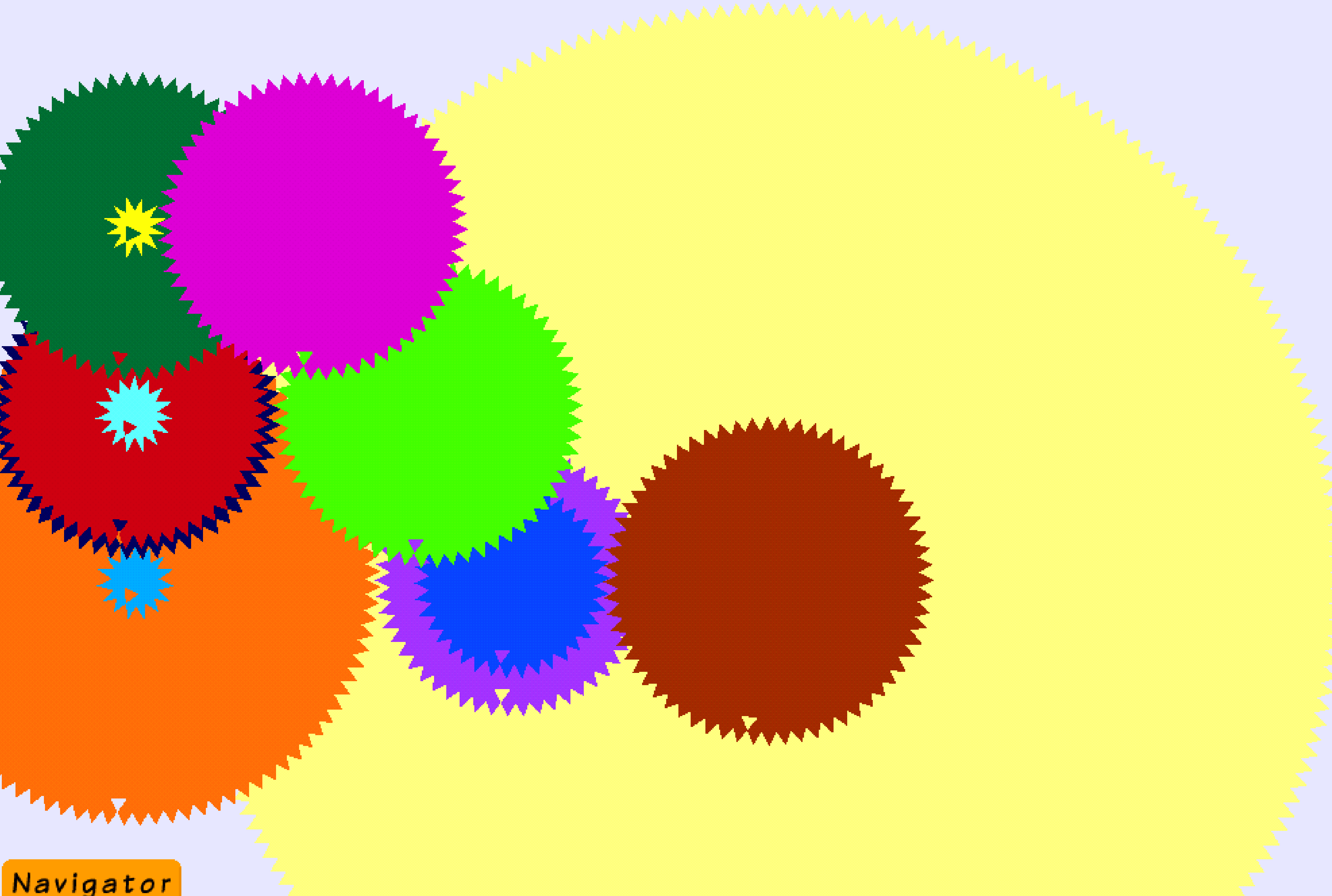
calendars
Metonic calendar
Olympiad
Callippic calendar
base
Year
m1
e3
eclipse
Saros
Exeligmos
lunar
(Sidereal month)
hipparchos
Anomalistic month
48 a1
224 b1
64 b2
38 l1
53 l2
96 m1
15 m2
53 n1
15 n2
57 n3
60 o1
60 p1
12 p2
60 q1
27 m3
223 e3
188 e4
53 f1
30 f2
54 g1
20 g2
60 h1
15 h2
60 i1
38 c1
48 c2
24 d1
127 d2
32 e2
50 e5
50 k1
50 k2
50 e6
32 e1
32 b3

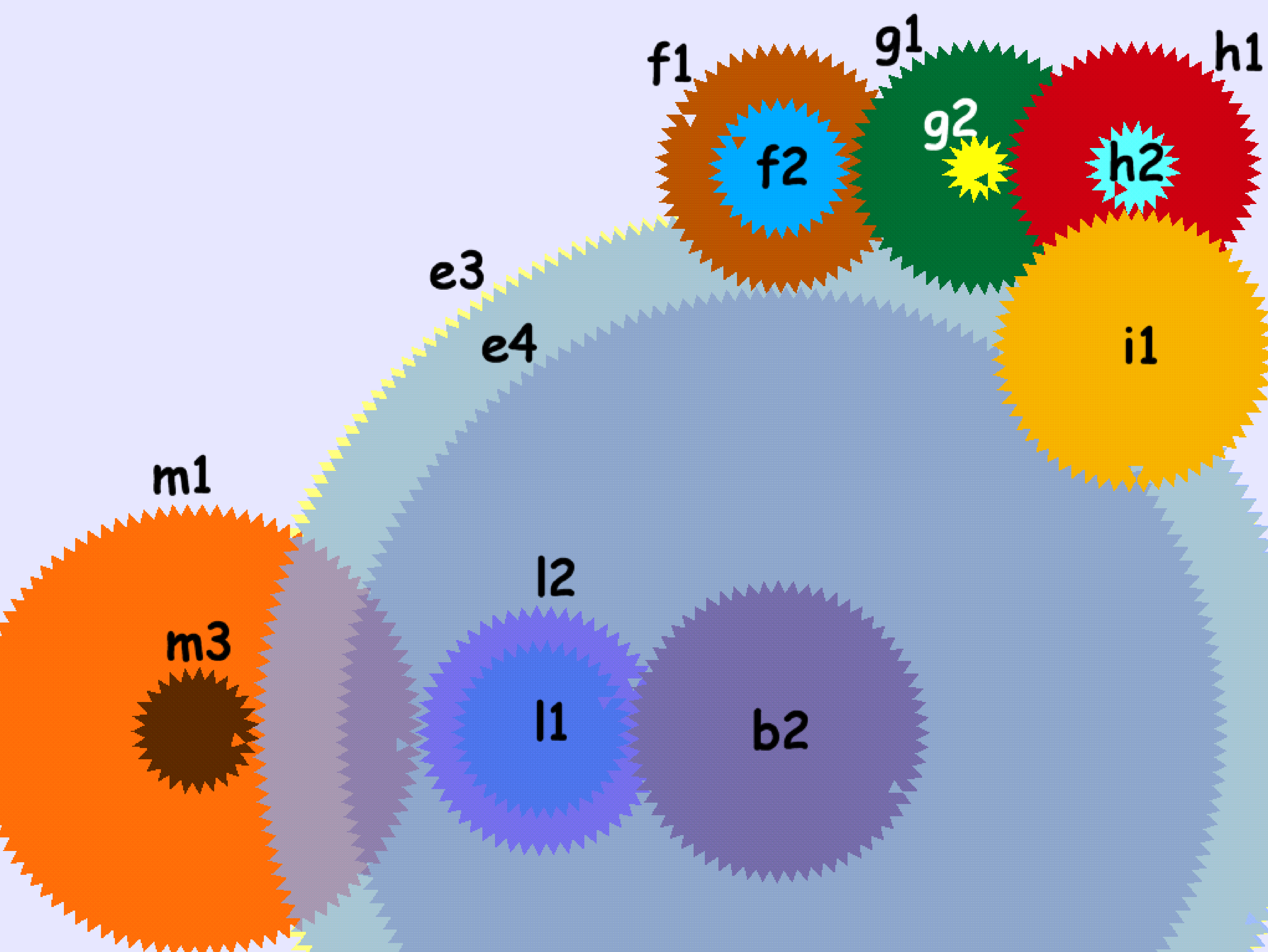

A
B
Cin
S
Cout

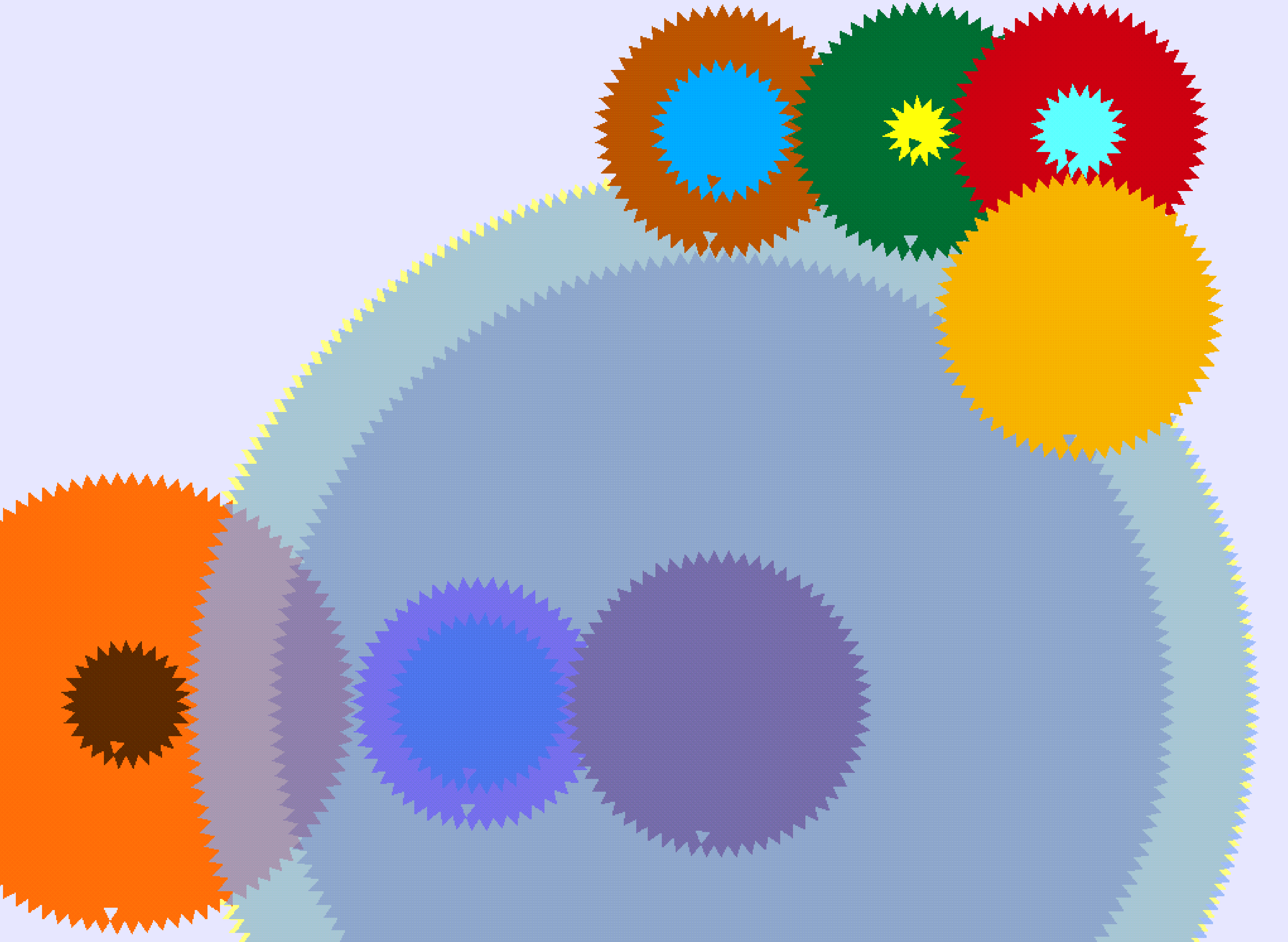

start baseSetup
no
bl gear: 224
bl movex: 570
bl movey: 240
b2 gear: 64
b2 coCenter: bl
start mlSetup
normal
ll gear: 38
ll west: b2
l2 gear: 53
l2 coCenter: ll
ll do menu item bring to front
b2 do menu item bring to front
ml gear: 96
start luniSolarSetup
norma
ml west: l2
m2 gear: 15
m2 coCenter: ml
nl gear: 53
nl north: m2
n3 gear: 57
n3 coCenter: nl
nl do menu item bring to front
n2 gear: 15
n2 coCenter: nl
pl gear: 60
pl north: n2
p2 gear: 12
p2 coCenter: pl
ol gear: 60
ol east: n3
ql gear: 60
ql east: p2
p1
p2
q1
b1
n2
o1
n1
n3
m2
l1
b2
m1
l2
Navigator

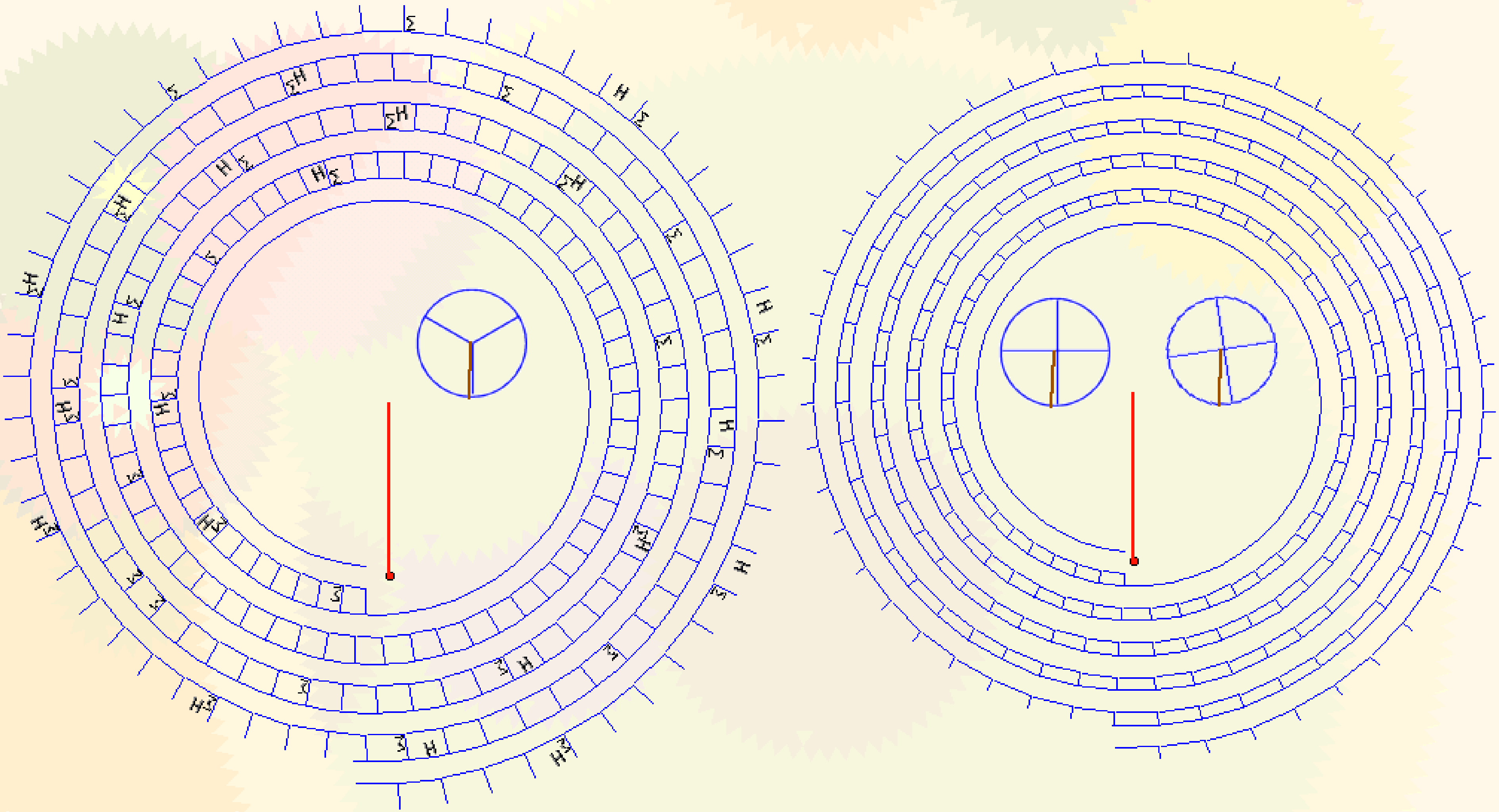


start baseOperate
normal
b1 turn by start's turn
sun's heading ← b1's heading
b2 sameHeading: b1
start luniSolarOperate
normal
m2 sameHeading: m1
n1 adjustCcw: m2
n2 sameHeading: n1
n3 sameHeading: n1
p1 adjust: n2
p2 sameHeading: p1
q1 adjustCcw: p2
o1 adjust: n3
p1
p2
q1
b1
n2
o1
n1
n3
l1
b2
m2
m1
l2
Navigator


Navigator

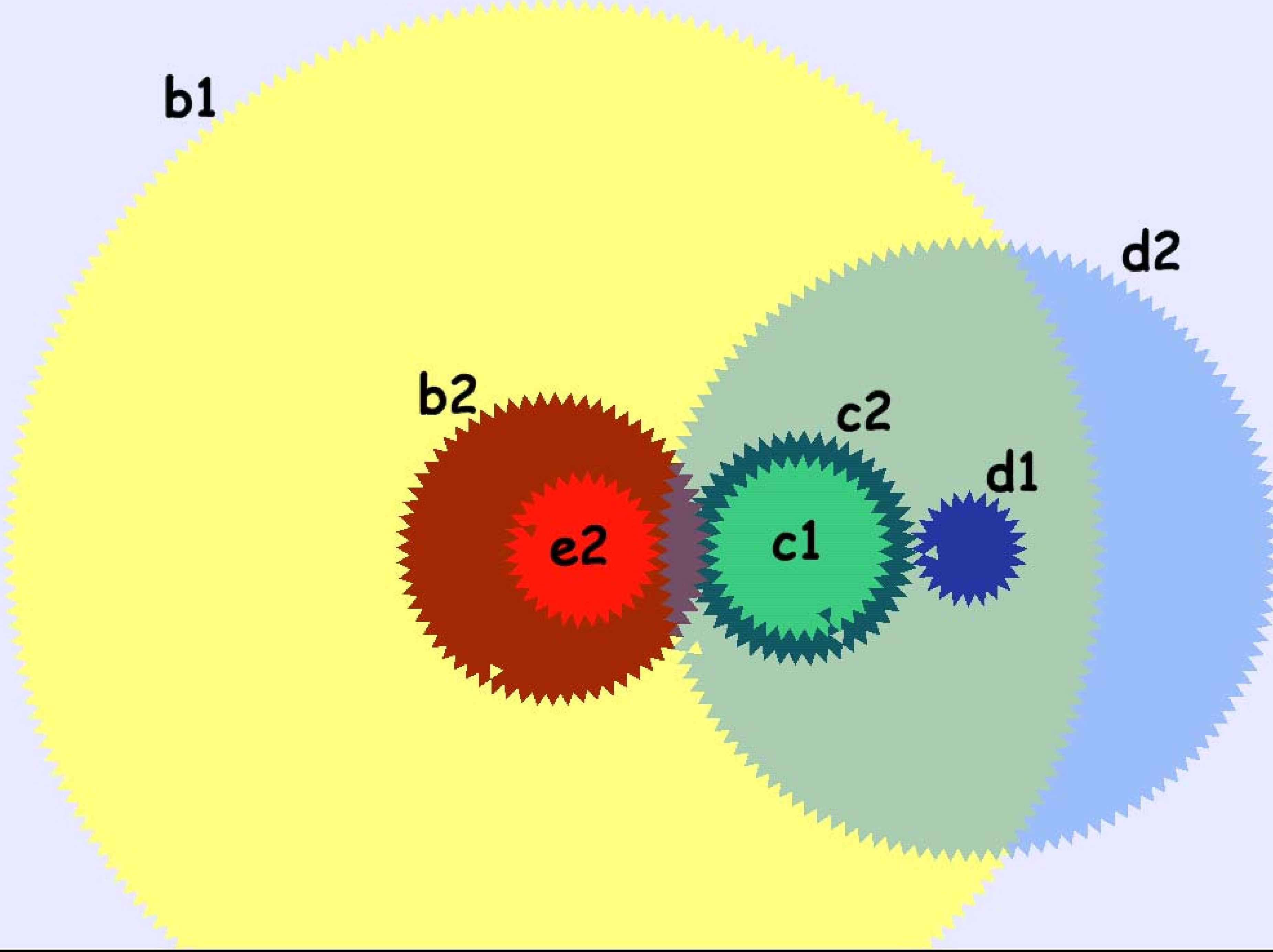

f1
g1
h1
f2
g2
h2
e3
e4
i1
m1
m3
l2
l1
b2

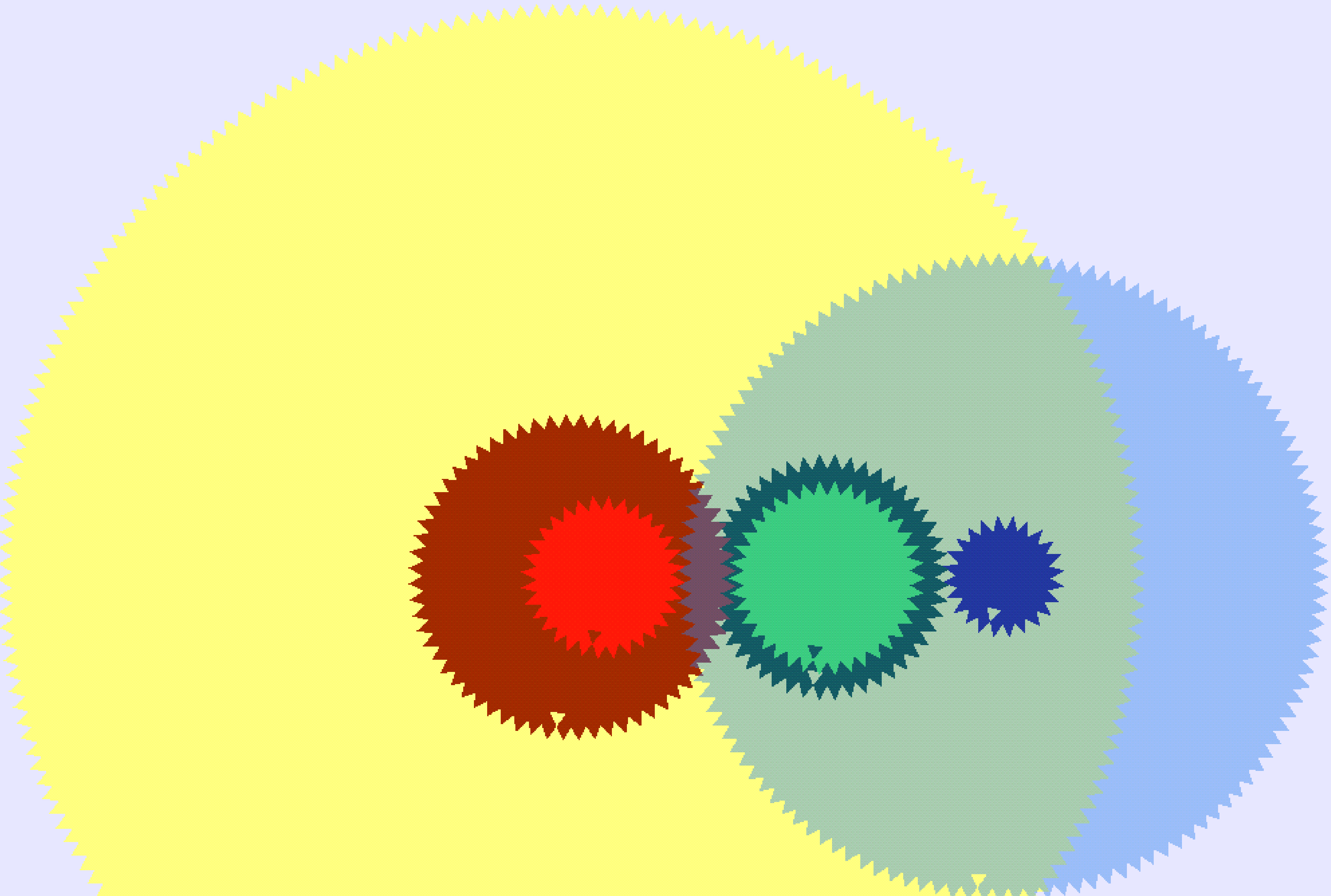




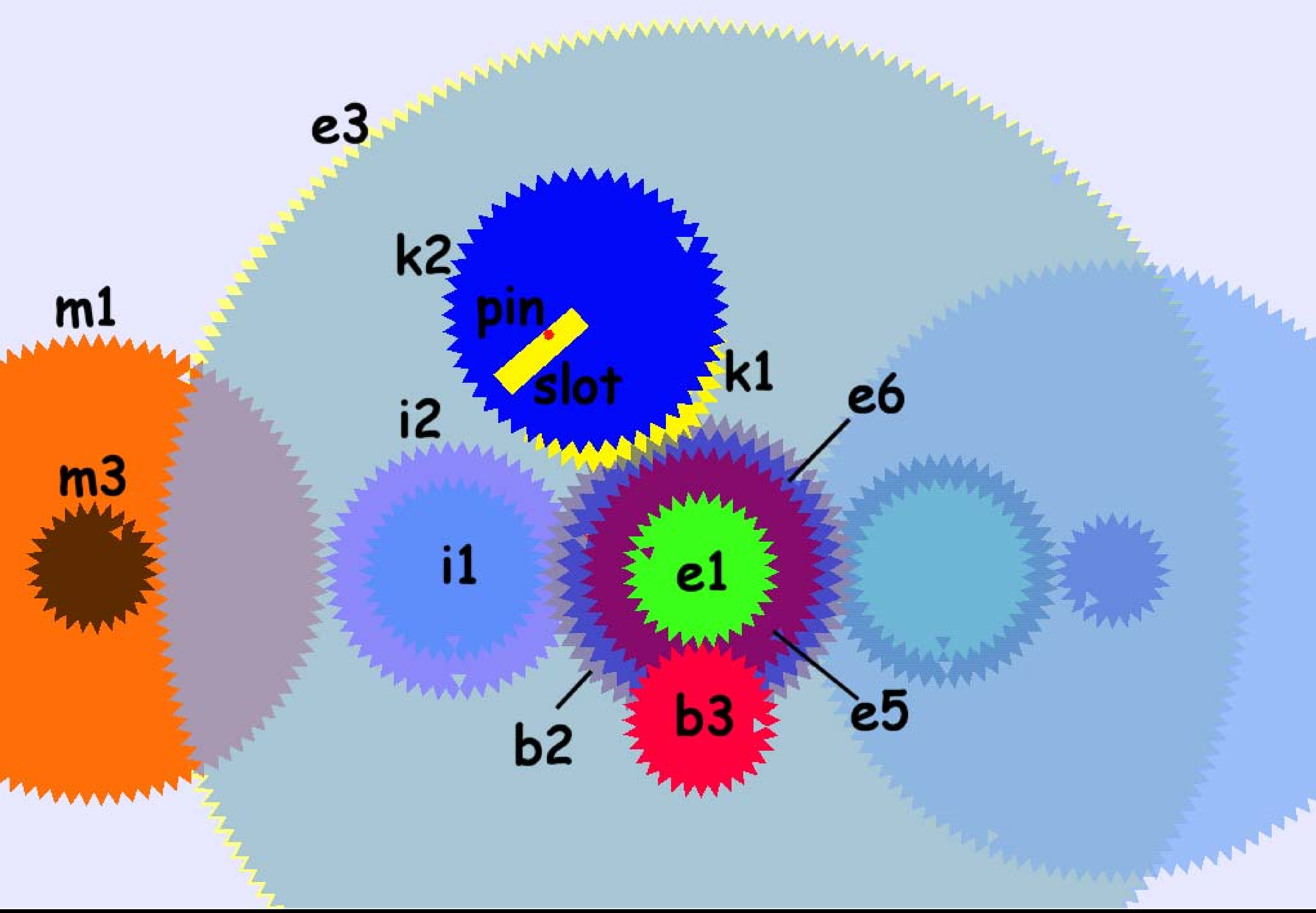
Navigator


EMT
0221


b1
d2
b2
c2
d1
e2
c1




Lunar perigee (33.48")
(356,700 km)
2007 Oct 26 12:02:39 UT
Lunar Apogee (29.40")
(406,300 km)
2007 Apr 3 08:50:54 UT
12% smaller


e3
k2
m1
pin
slot
k1
e6
i2
m3
i1
e1
b3
e5
b2

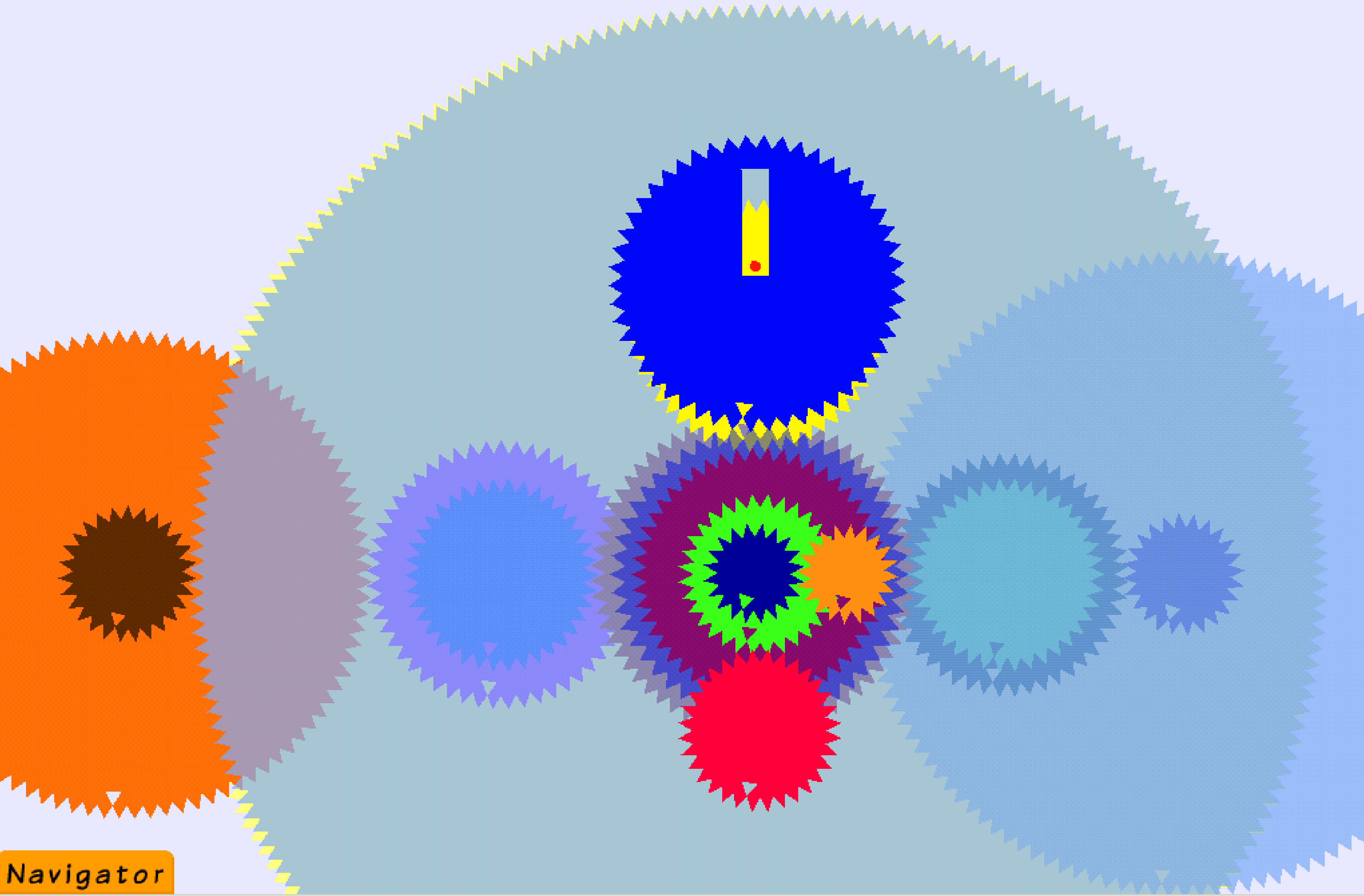
DVI

High-Speed PCB Design Considerations

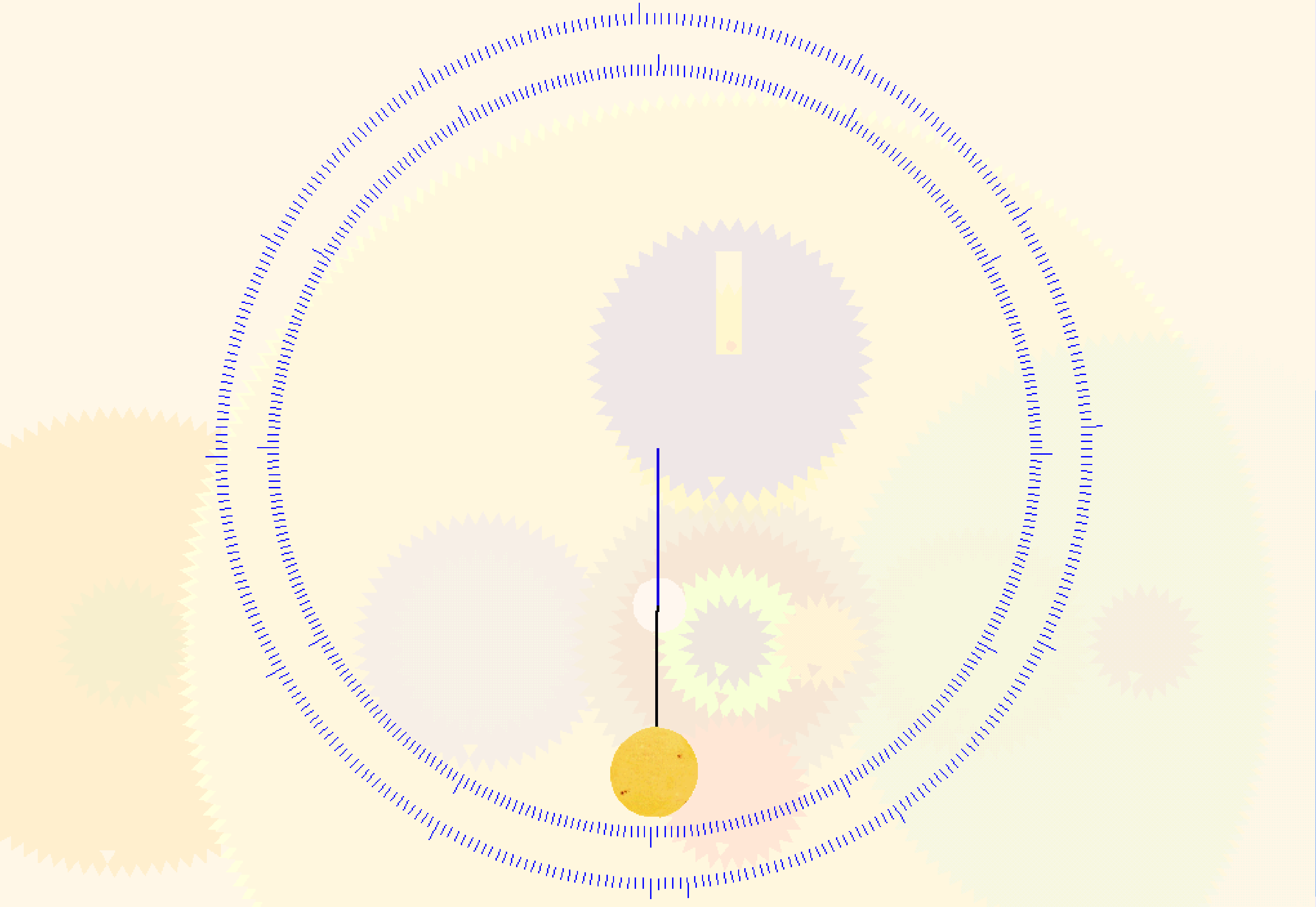
December 2006 Technical Note TN1033

PCB Design Checklist

1. Use 100 ohm differential impedance pairs on PCB. Controlled impedance lines should be specified in the PCB layout mechanical drawing.
2. Match trace lengths in a pair with tolerance of 20% of the signal rise/fall time.
3. Use connectors that are designed and characterized at the highest data frequency. (Vendors should provide characterization and model data.)
4. Use stripline construction with ground/power planes above and below the differential pairs. The ground and power planes also provide return paths for signal currents.
5. Use edge-coupled pairs in PCBs; try to avoid broadside coupled pairs.
6. Use 3 S separation rules between pairs to avoid crosstalk and excess coupling. Use offset stripline routing to get higher density of differential pairs with each routing layer running orthogonal to each other.



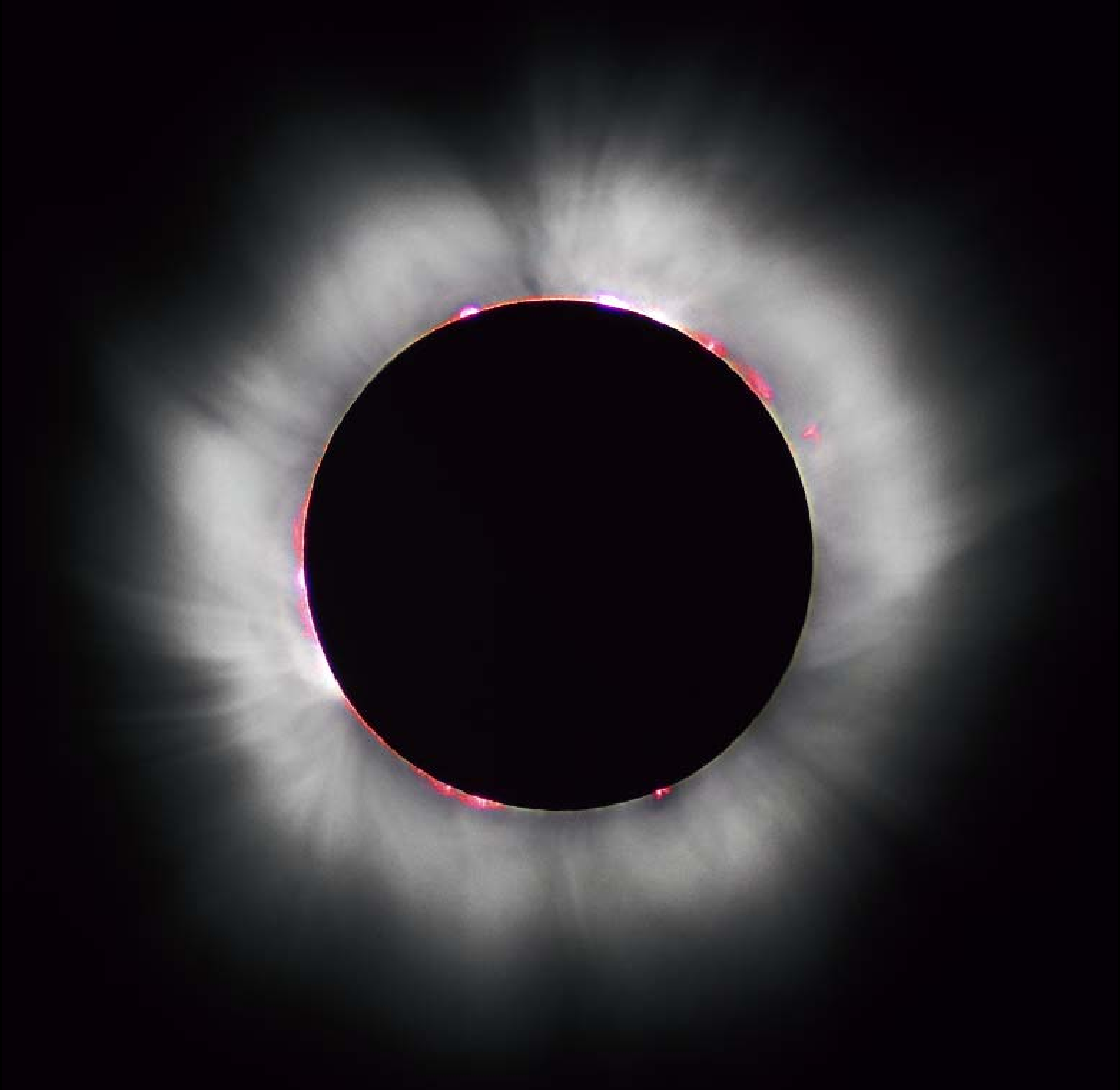
Navigator



Navigator

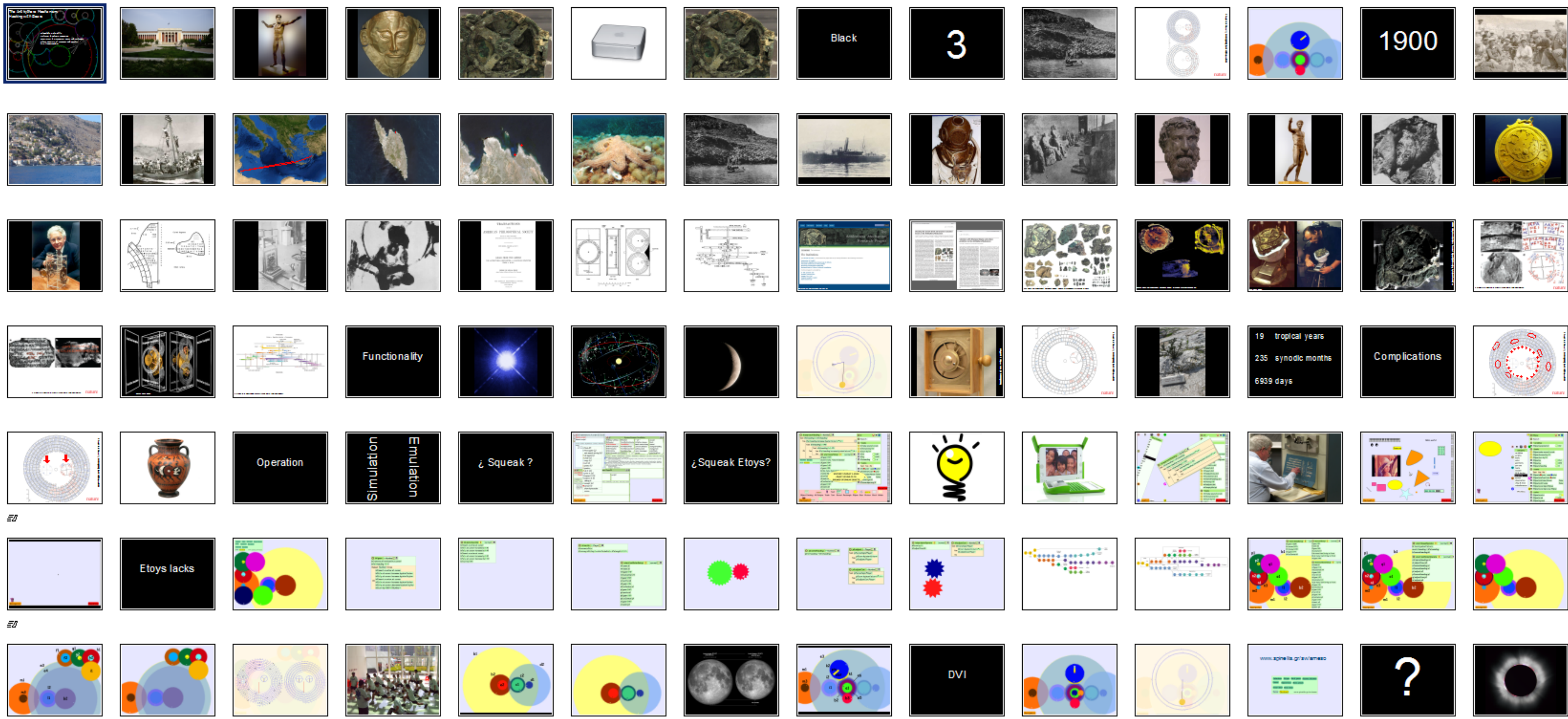
www.spinellis.gr/sw/ameso

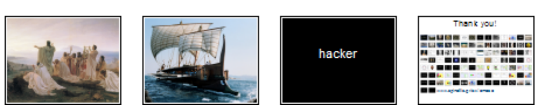
?



hacker

Thank you!





www.spinellis.gr/sw/ameso