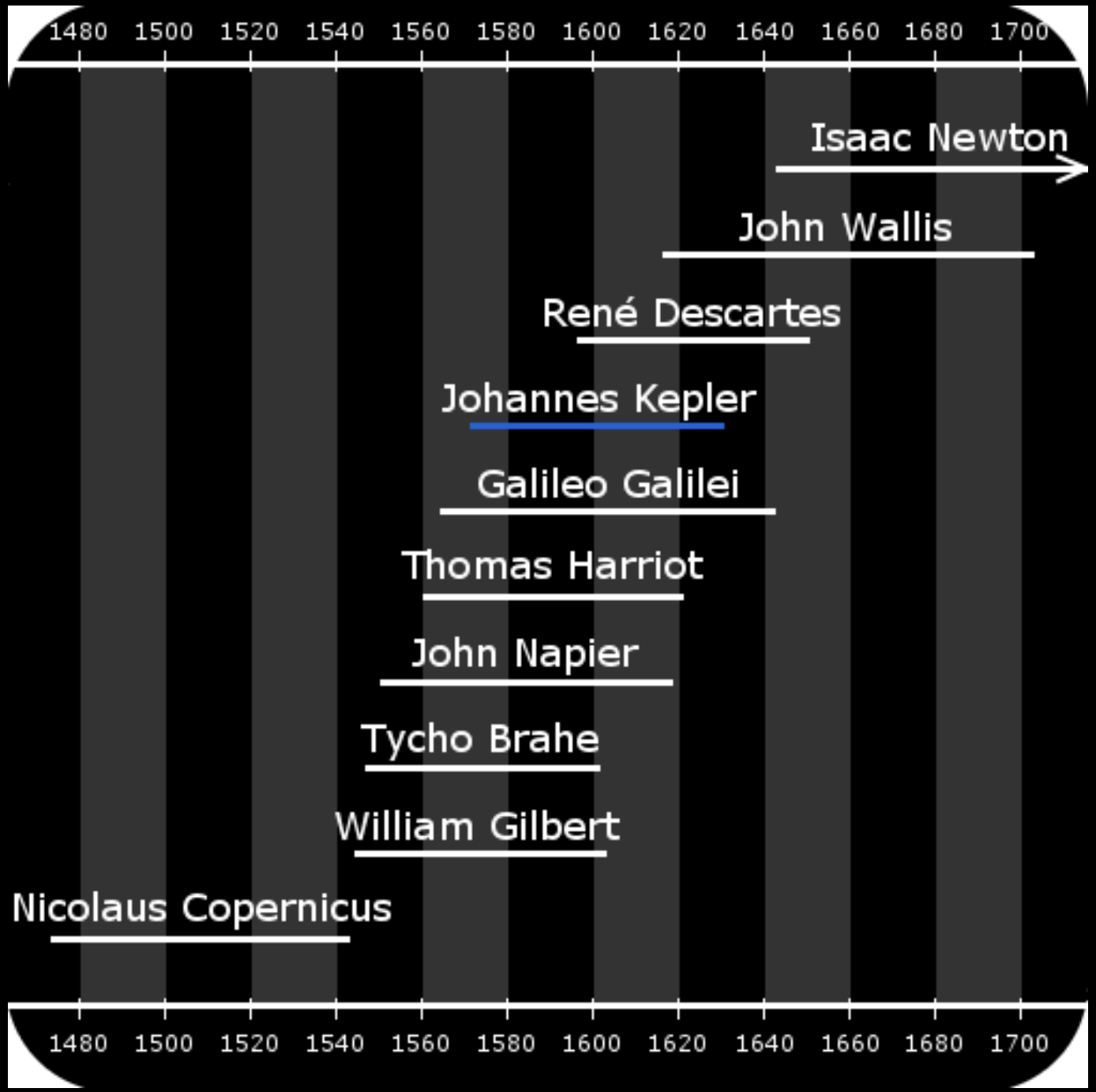
Johannes Kepler

. . . and the Rules of the Solar System


1480 1500 1520 1540 1560 1580 1600 1620 1640 1660 1680 1700
Isaac Newton
John Wallis
René Descartes
Johannes Kepler
Galileo Galilei
Thomas Harriot
John Napier
Tycho Brahe
William Gilbert
Nicolaus Copernicus
1480 1500 1520 1540 1560 1580 1600 1620 1640 1660 1680 1700


Maulbronn
Württemberg
Leonberg
Stuttgart
Weil der Stadt
Adelberg
Tübingen
Ulm

- Born December 27, 1571 (28 years after Copernicus's death)
- Galileo & Shakespeare were both 7 yrs old
- First born to Heinrich & Katherina Kepler (both 24), married May 16 (?)
- Catholic vs. Lutheran


STADTMUSEUM

Family moves to Leonberg

Great Comet

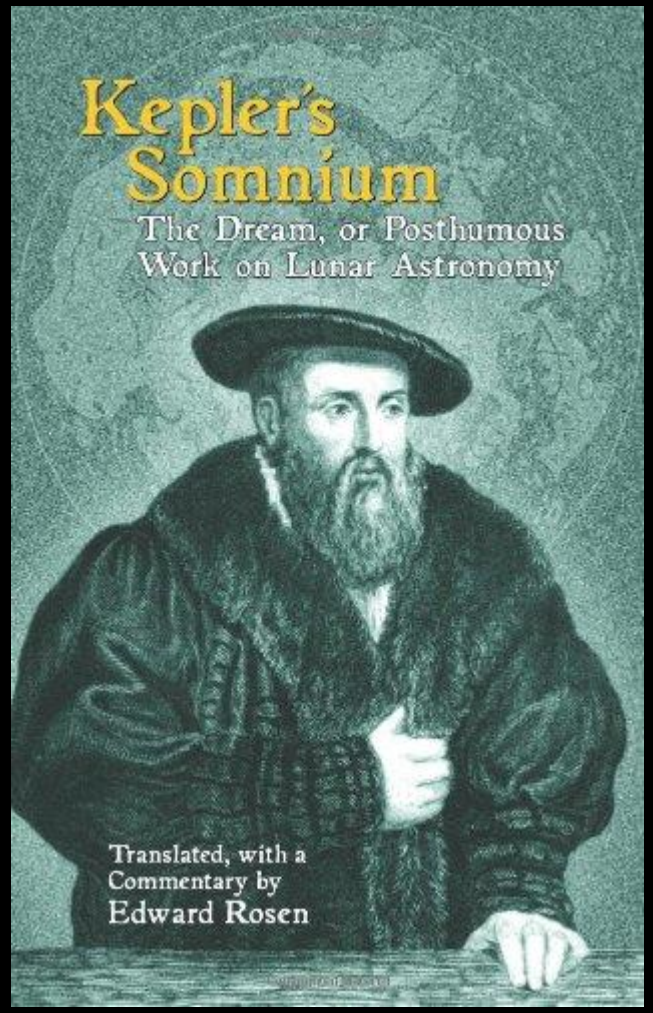

Seminary at Maulbronn

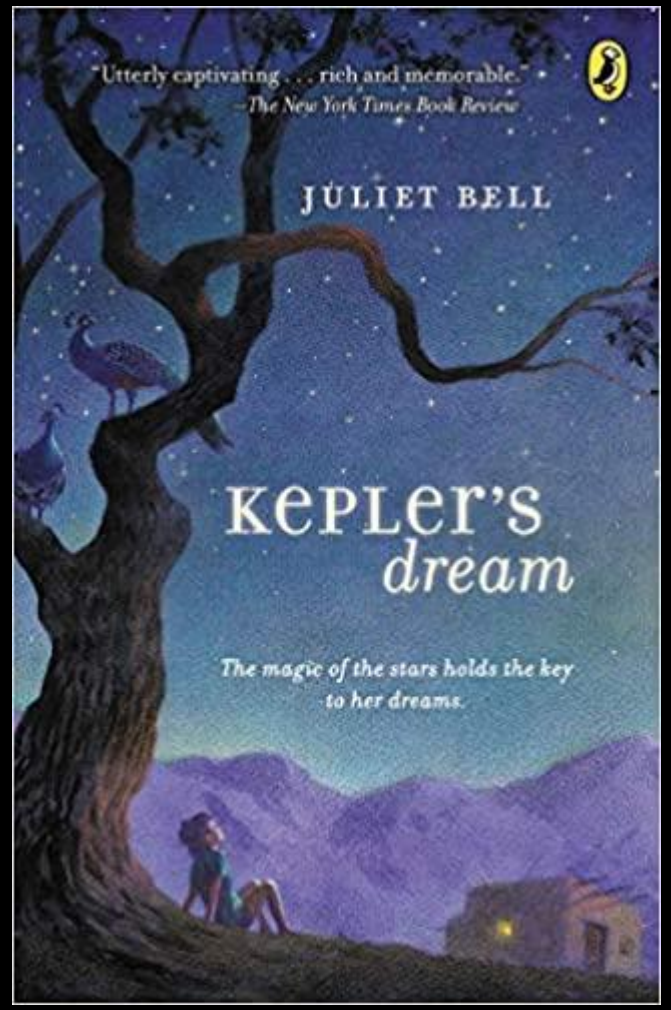
University of Tübingen

IOH. KEPPLERI
MATHEMATICI
OLIM IMPERATORII
SOMNIVM,
Seu
OPVS POSTHVMVM
DE ASTRONOMIA
LVNARI.
Divulgatum
à
M. LUDOVICO KEPPLERO FILIO,
Medicinæ Candidato.

Impressum partim Sagani Silesiorum, absolutum Francofurti, sumptibus hæredum authoris.

ANNO M DC XXXIV.






Prague
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Ingolstadt
Lower
Austria
Linz
Ulm
Augsburg
Bavaria
Upper
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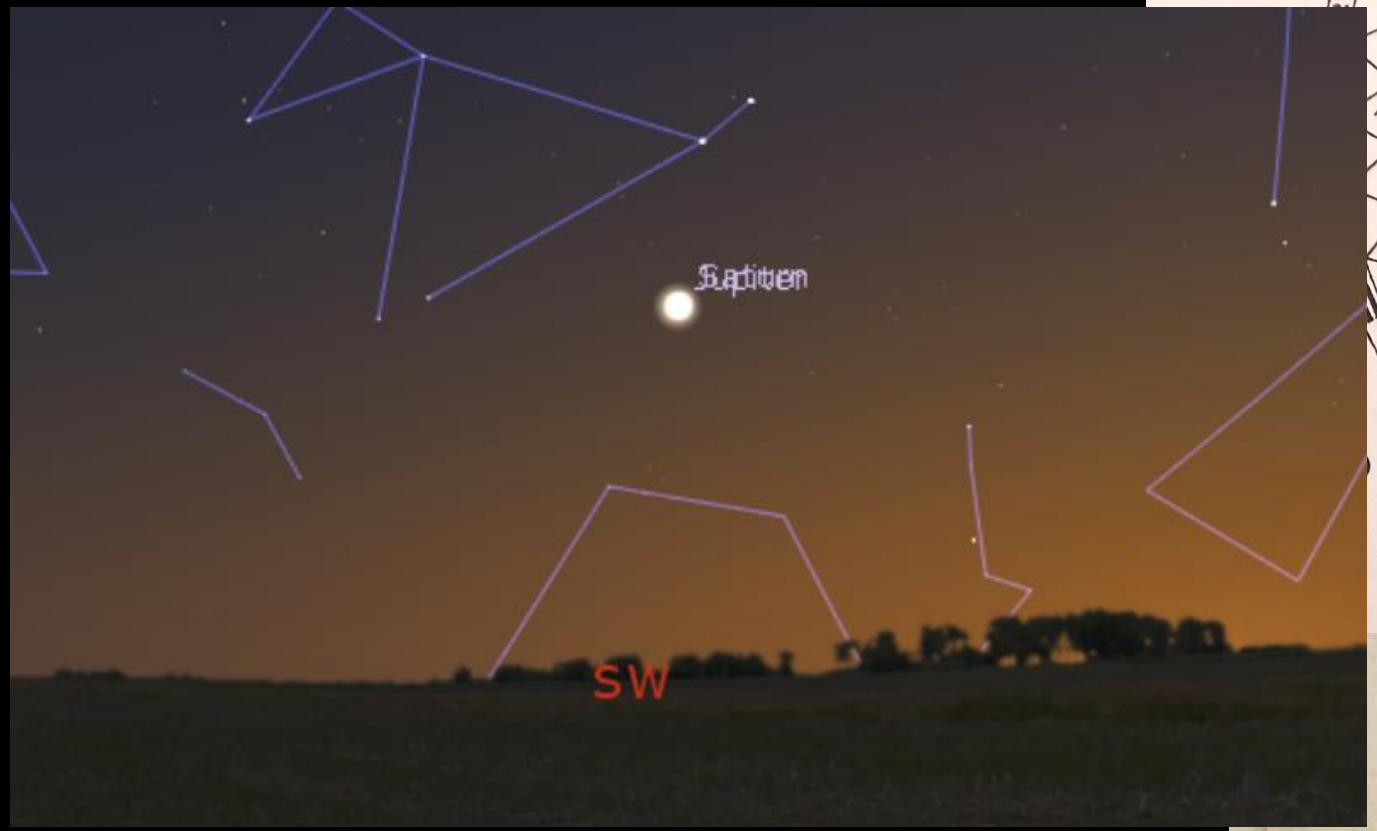
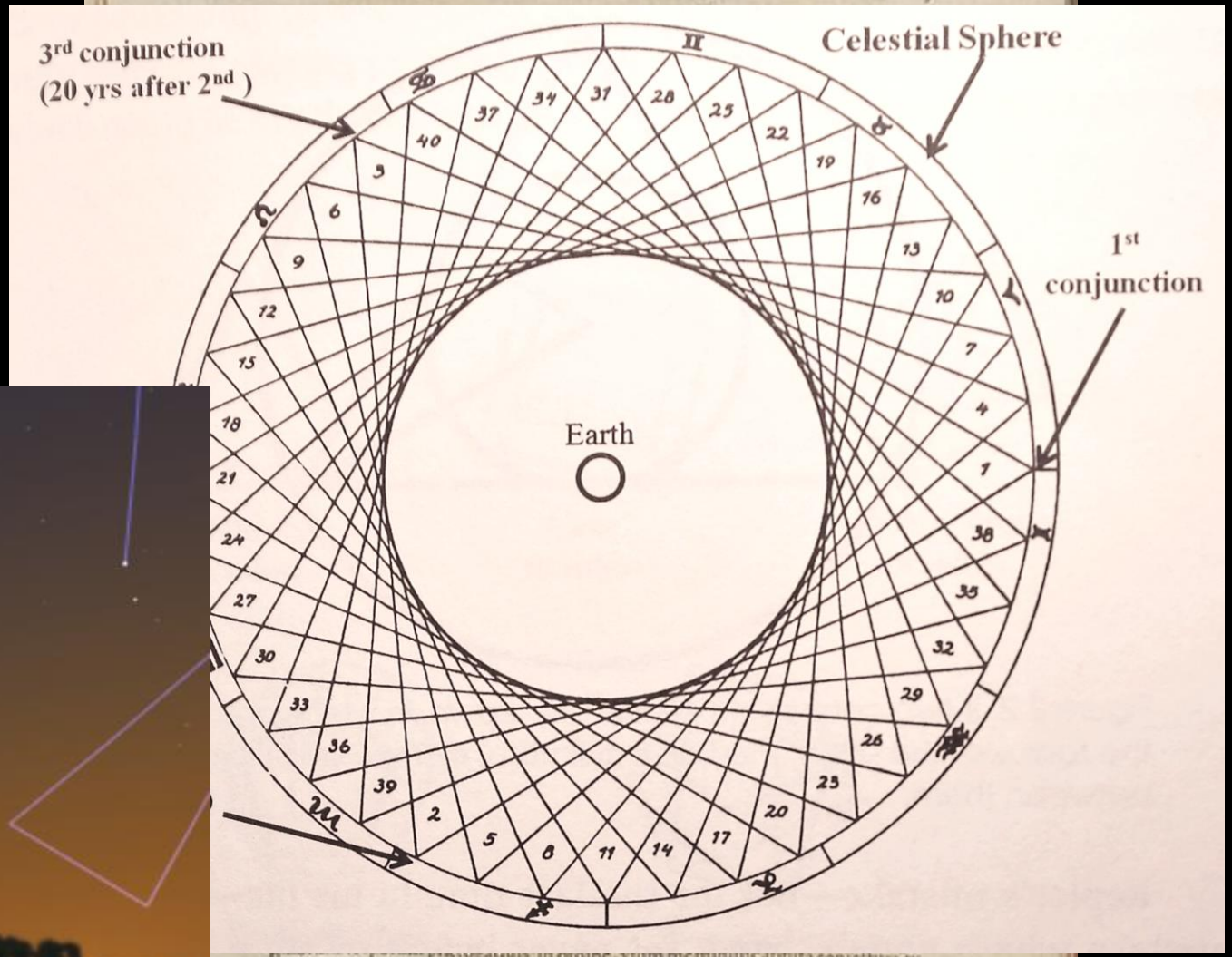
Vienna
Styria
Graz

“Great Conjunctions”





Prodromus
DISSERTATIONVM COSMOGRAPHICARVM,
continens

MYSTERIVM COSMOGRAPHICVM

DE ADMIRABILI PROPORTIONE ORbium cœleſtium: deque cauſis cœlorum numeri, magnitudinis, motuumque periodicorum genuinis & propriis,

Demonſtratum per quinque regularia corpora Geometrica.

Libellus primum Tübingæ in lucem datus Anno Chriſti
M. D XCVI.

à

M. IOANNE KEPLERO VVIRTEMBERGICO, TVNC TEMPOris Illuſtrium Styriæ Prouincialium Mathematico.

Nunc vero poſt annos 25. ab eodem authore recognitus, & Notis notabiliſſimis partim emendatus, partim explicatus, partim confirmatus: deniq; omnibus ſuis membris collatus ad alia cognati argumenti opera, quæ Author ex illo tempore ſub duorum Impp. Rudolphi & Matthiæ auſpiciis; etiamq; in Illuſtr. Ord. Auſtriæ Supr-Aniſanæ clientela diuerſis locis edidit.

Potiſſimum ad illuſtrandas occaſiones Operis, Harmonice Mundi, dicti, eiuſque progreſſuum in materia & methodo.

Additæ eſt erudita NARRATIO M. GEORGII IOACHIMI RHETICI, de Libris Reuolutionum, atque admirandis de numero, ordine, & diſtantiis Sphærarum Mundi hypotheſibus, excellentiſſimi Mathematici, totiuſque Aſtronomiæ Reſtauratoris D. NICOLAI COPERNICI.

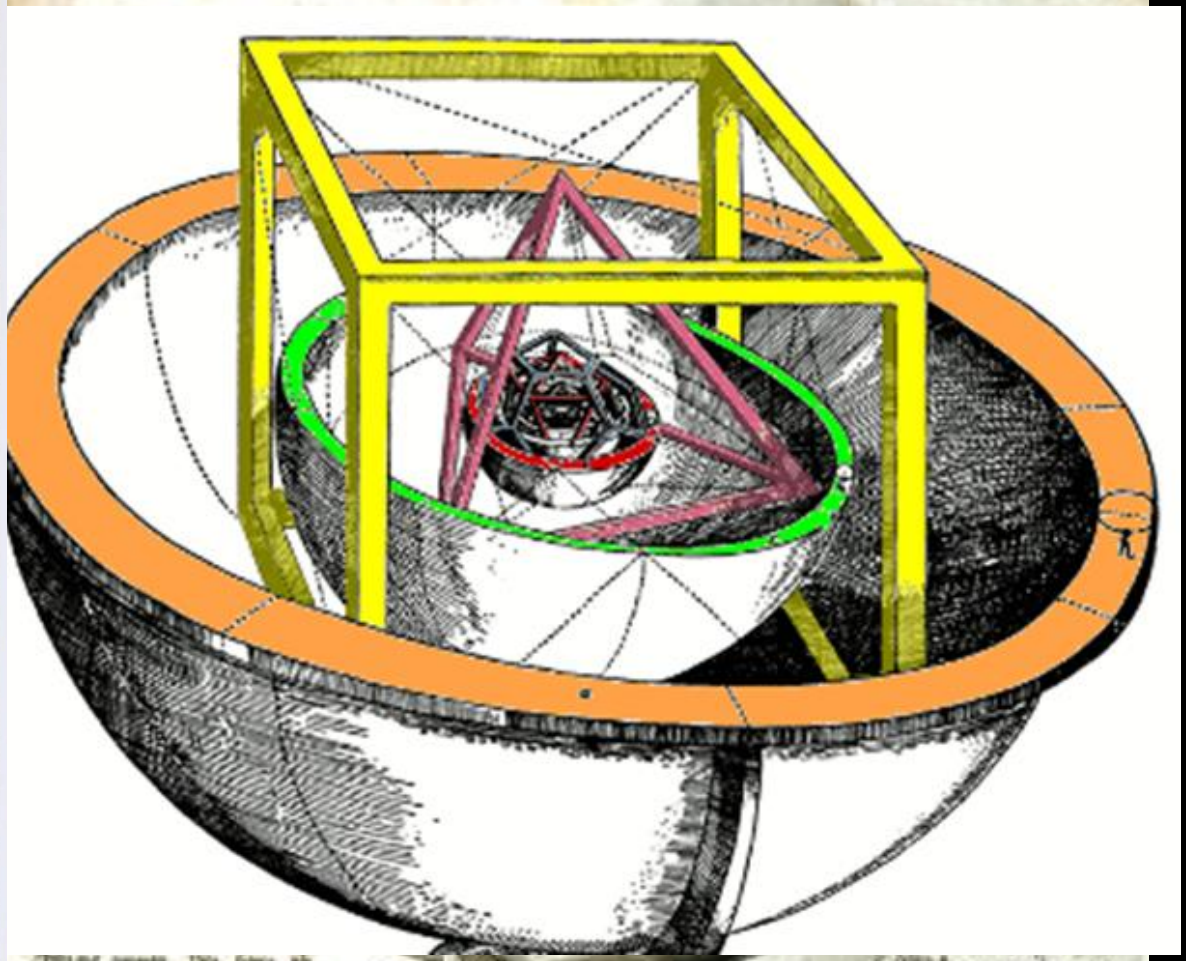
ITEM,

Eiuſdem IOANNIS KEPLERI *pro ſuo Opere Harmonices Mundi* APOLOGIA *aduerſus Demonſtrationem Analyticam Cl. V. D. Roberti de Fluctibus, Medici Oxonienſis.*

Cum Priuilegio Cæſareo ad annos XV.

FRANCOFVRTI,
Recuſus Typis ERASMI KEMPFERI, ſumptibus
GODEFRIDI TAMPACHII.

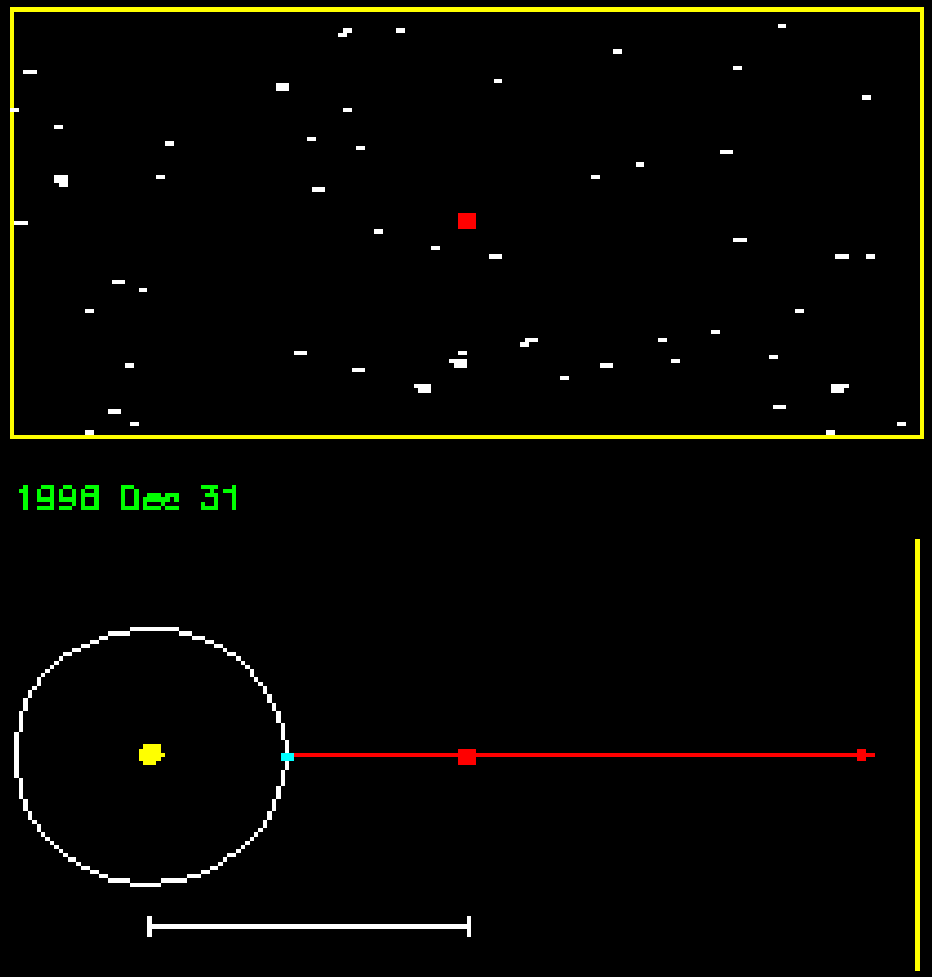
Anno M. DC. XXI.



Tycho Brahe

- “Gold nose”
- Greatest observer (without a telescope)
- “Showed” Earth does not move (“parallax”)
- Needed math dude to crunch data
- “Partied too hard!”

No “parallax”

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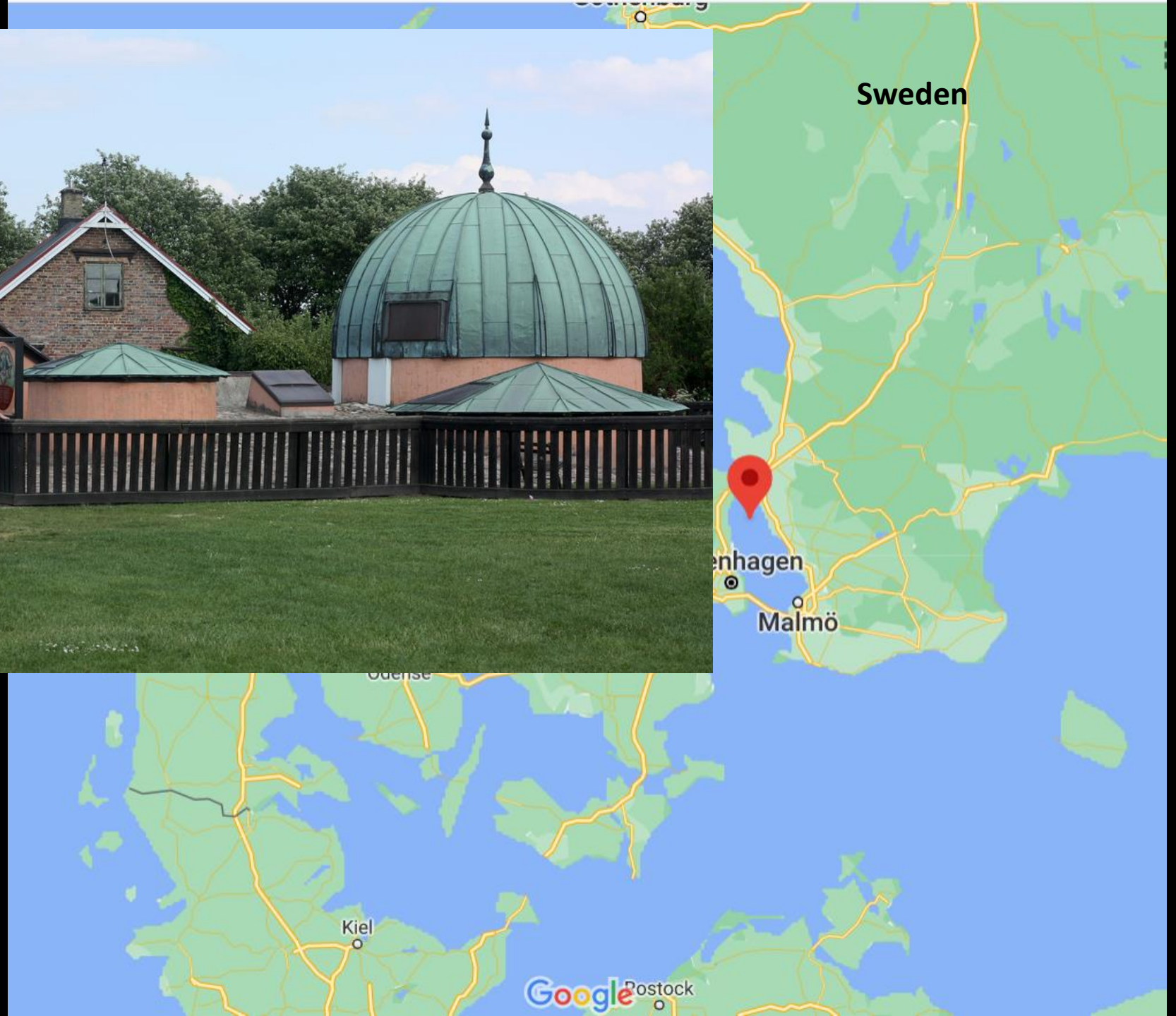
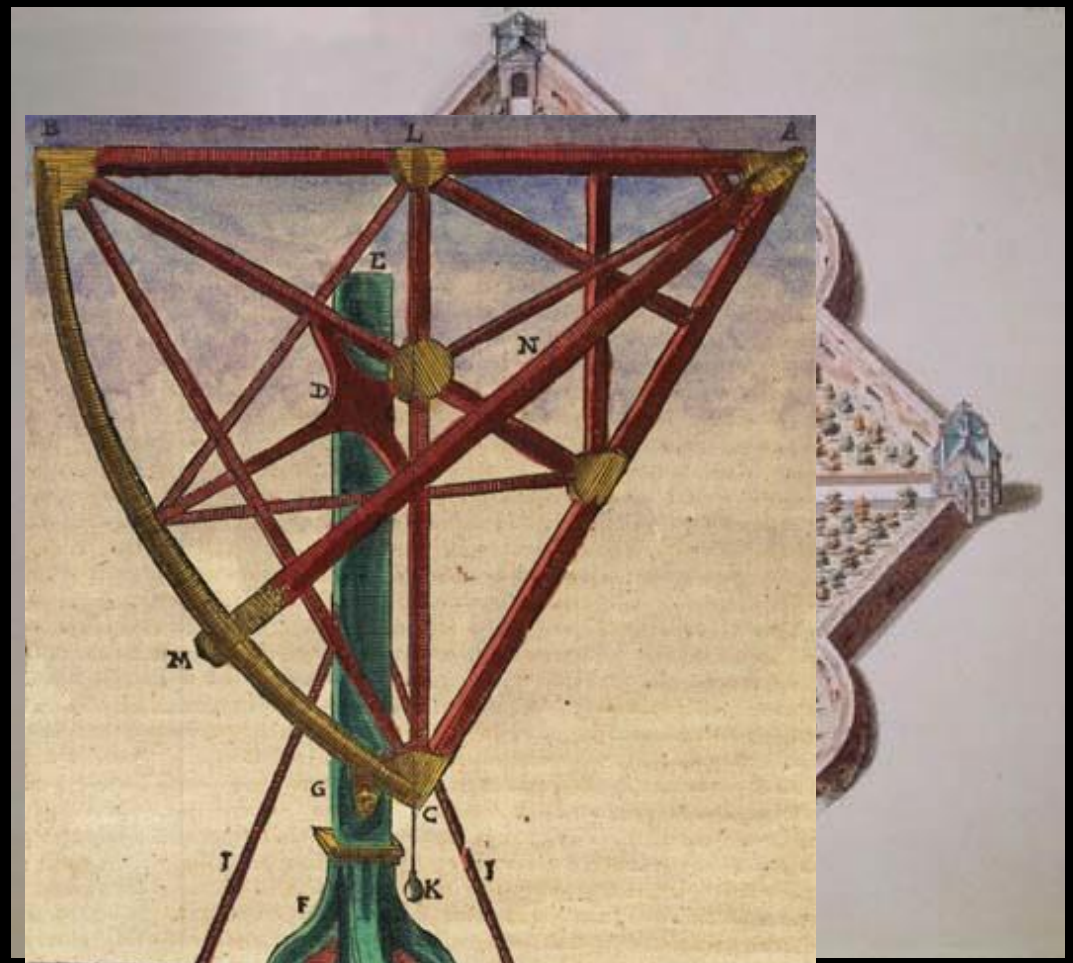

Sweden
Malmö
Kiel
Rostock
Google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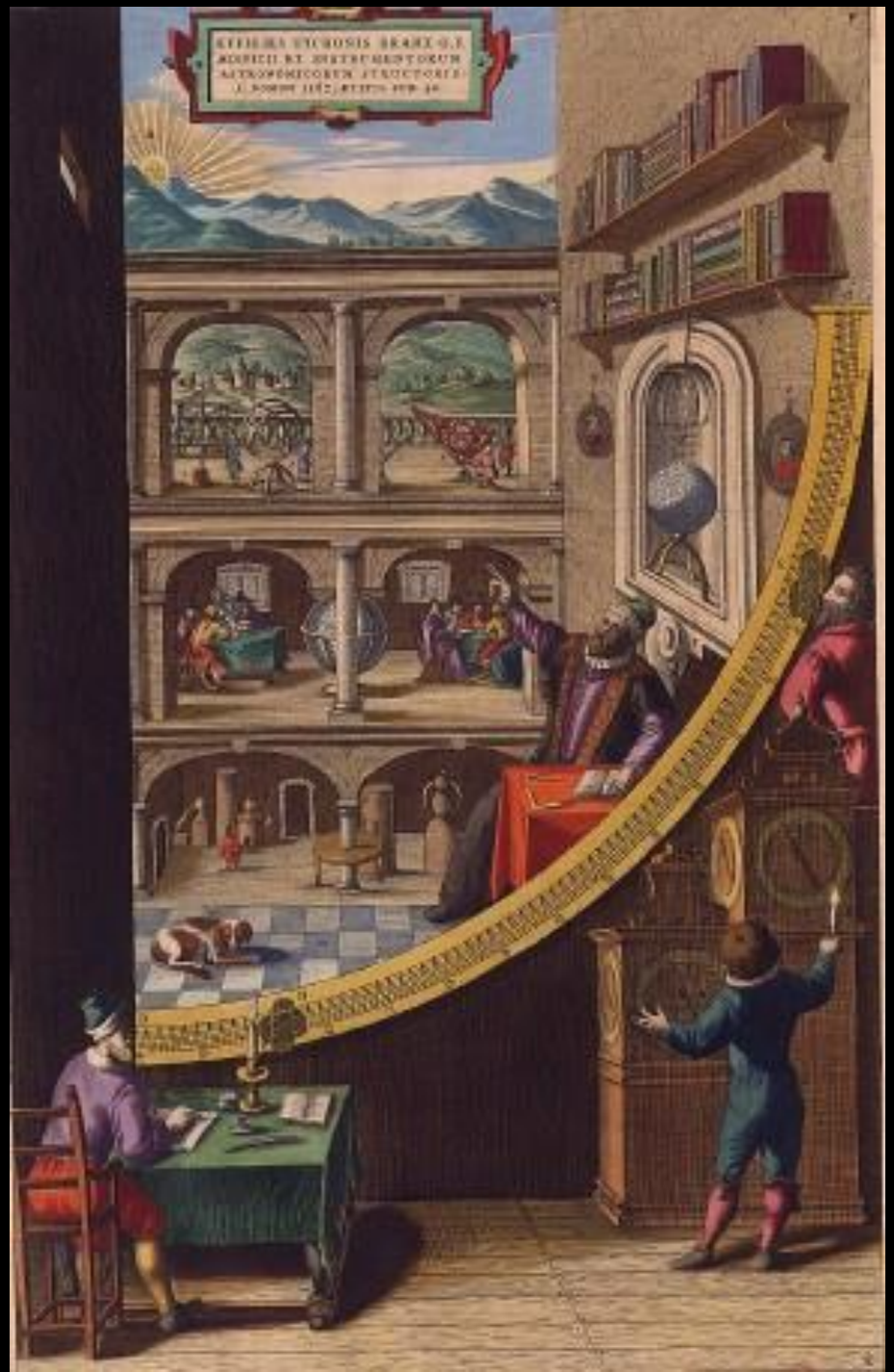
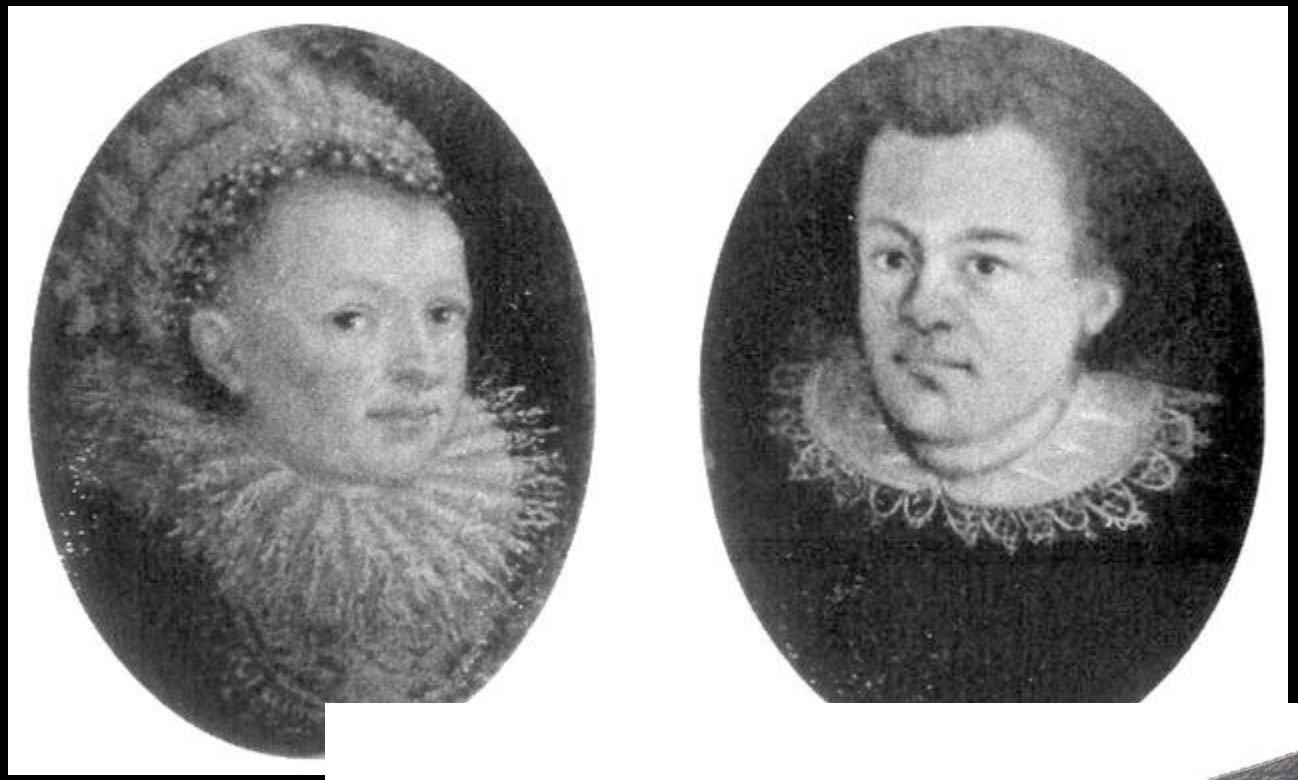
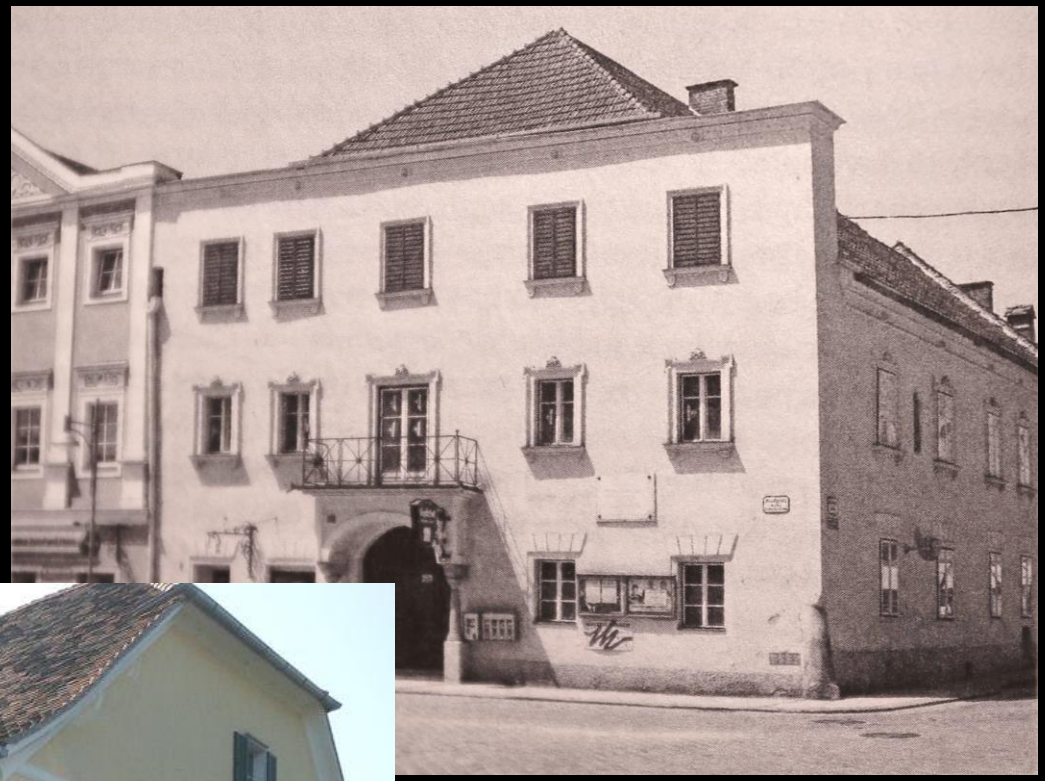
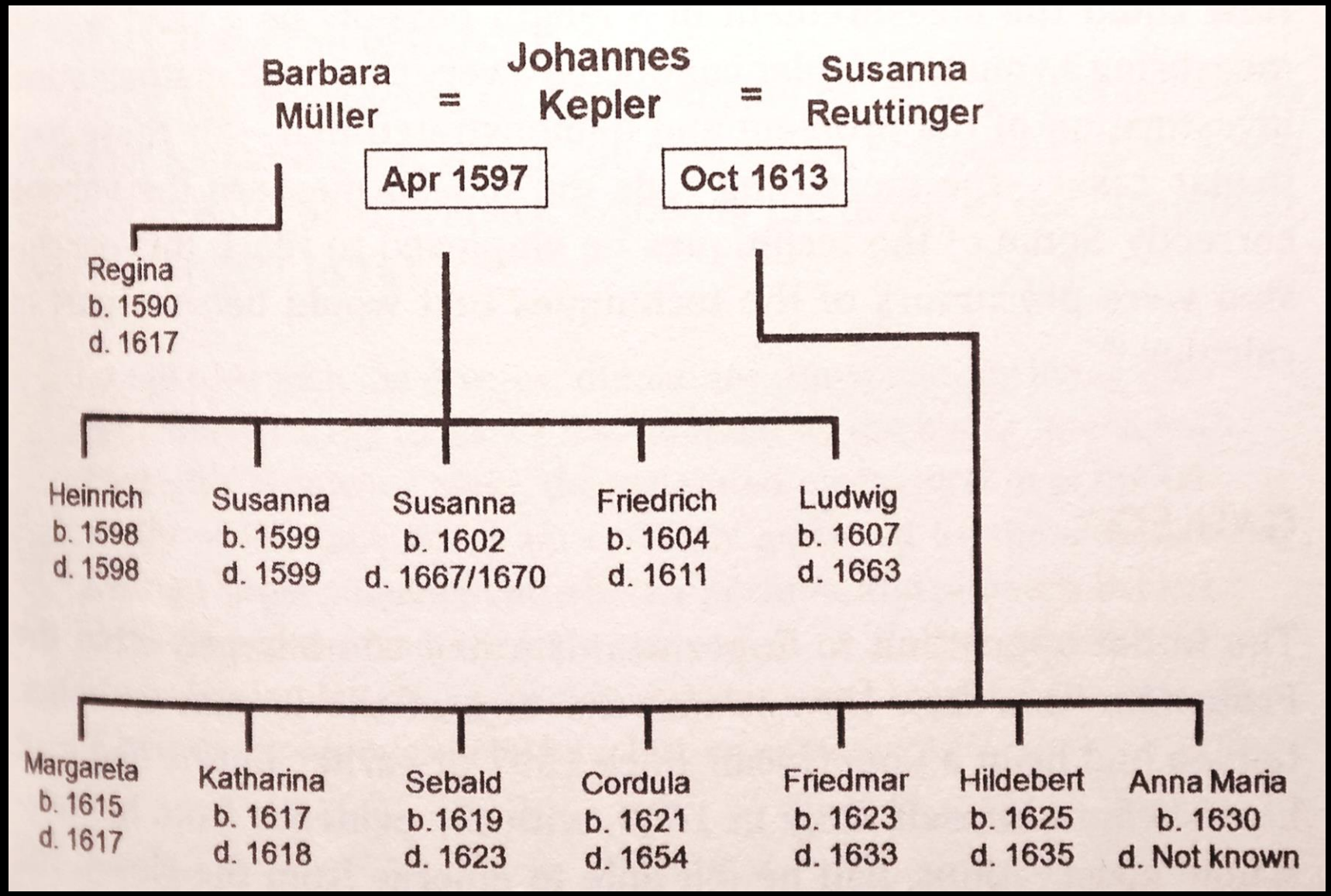


Tychonic Universe

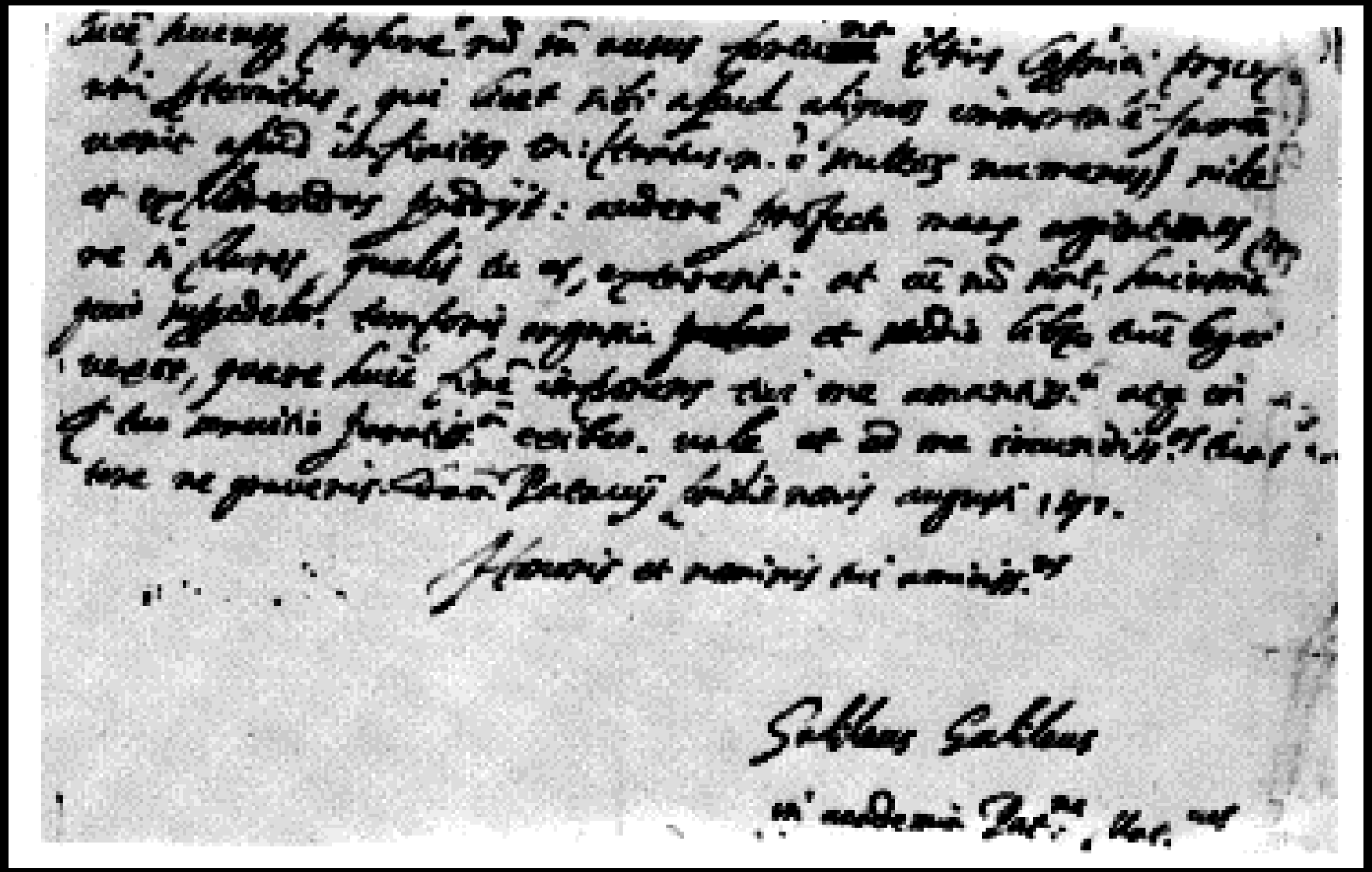




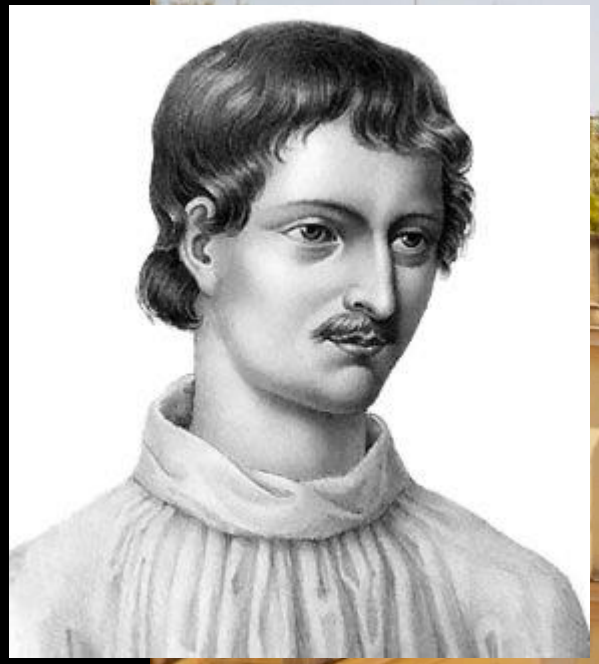
Kepler Family tree



Letter from Galileo (1597)

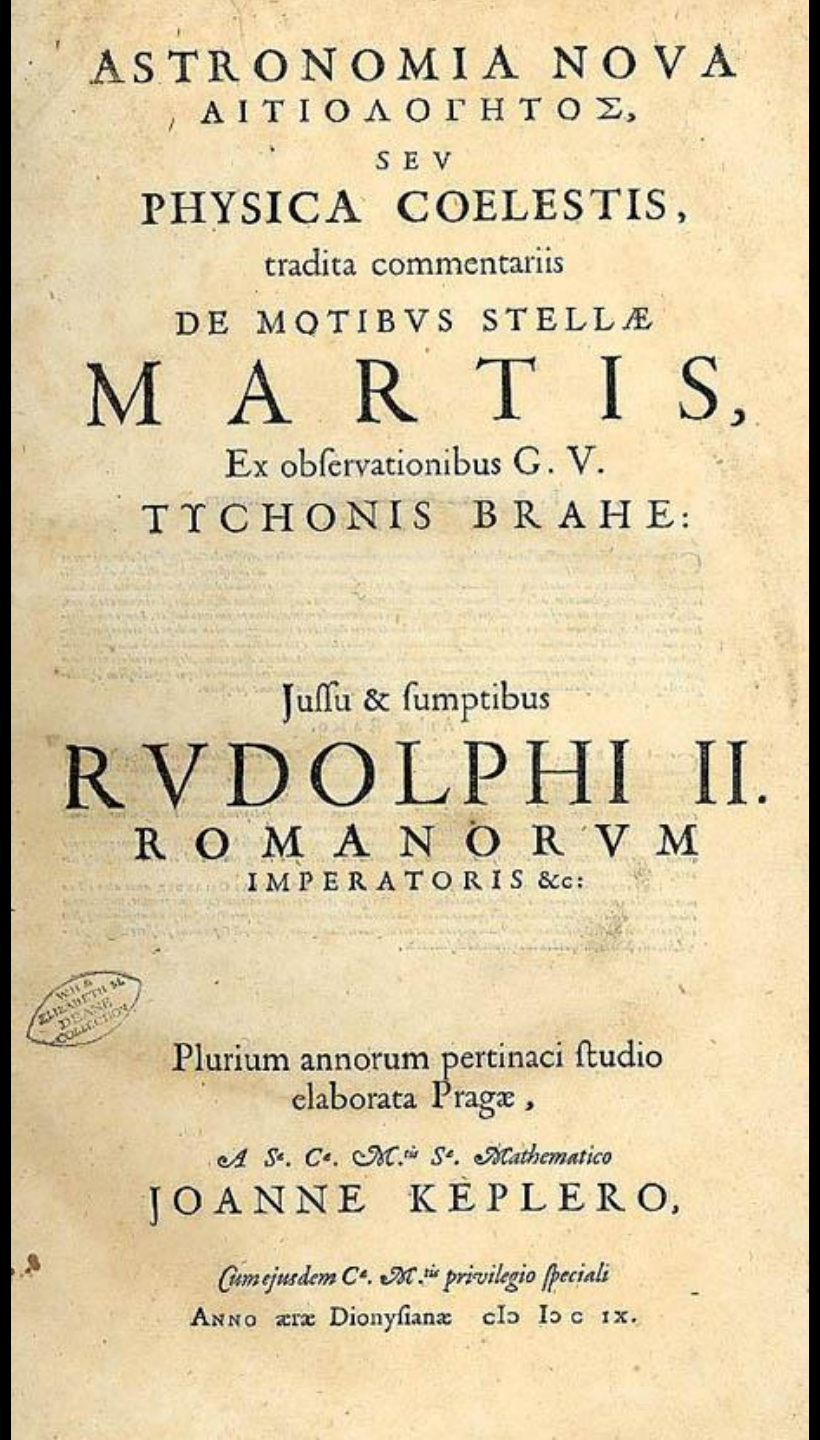


A “shout out” to Giordano Bruno



Tycho meets Kepler (1600)

Benatky Castle



ASTRONOMIA NOVA
AITIOΛOΓHTOΣ,
SEV
PHYSICA COELESTIS,
tradita commentariis
DE MOTIBVS STELLÆ
MARTIS,
Ex obſervationibus G. V.
TYCHONIS BRAHE:

Juſſu & ſumptibus
RVDOLPHI II.
ROMANORVM
IMPERATORIS &c:

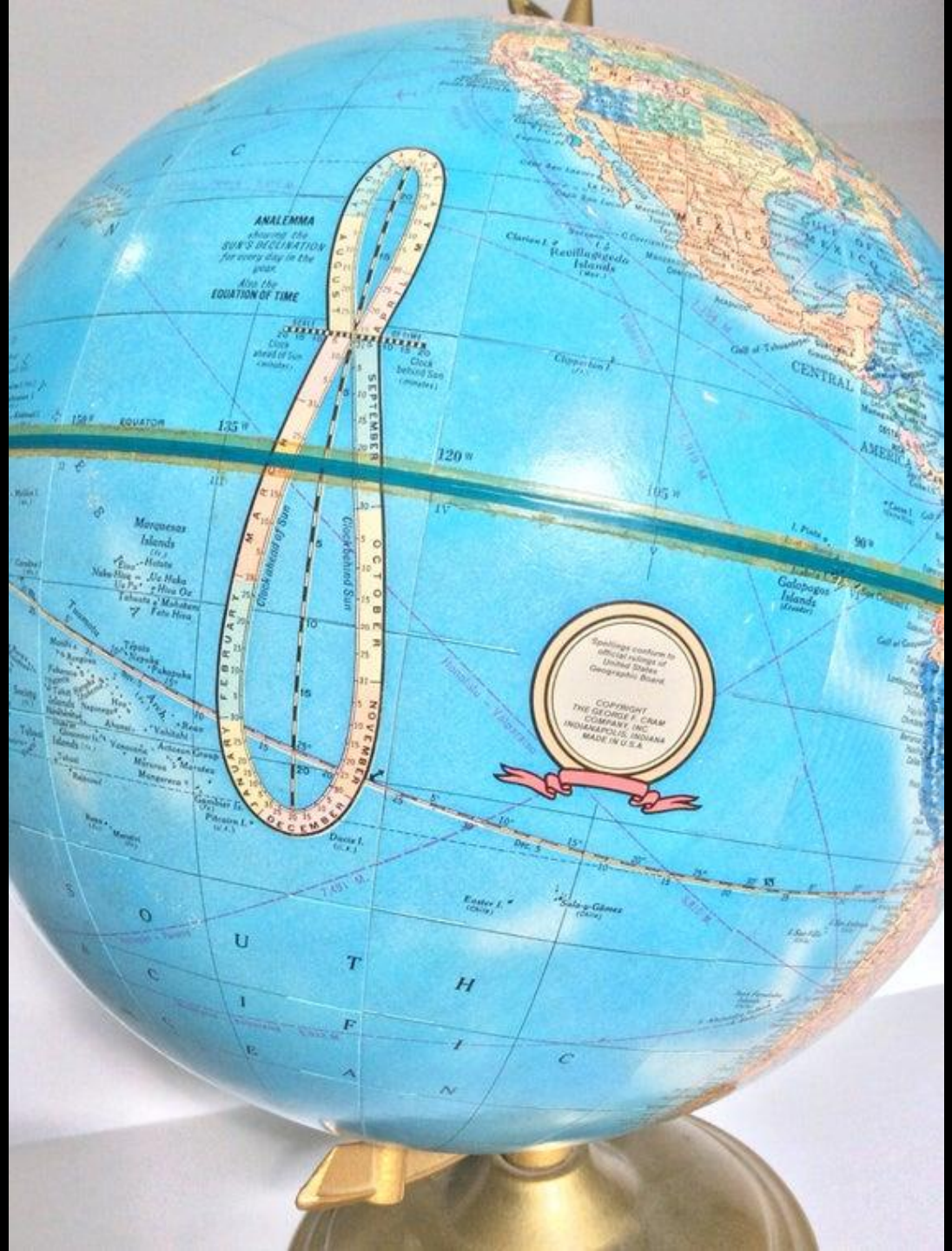
Plurium annorum pertinaci ſtudio
elaborata Pragæ,

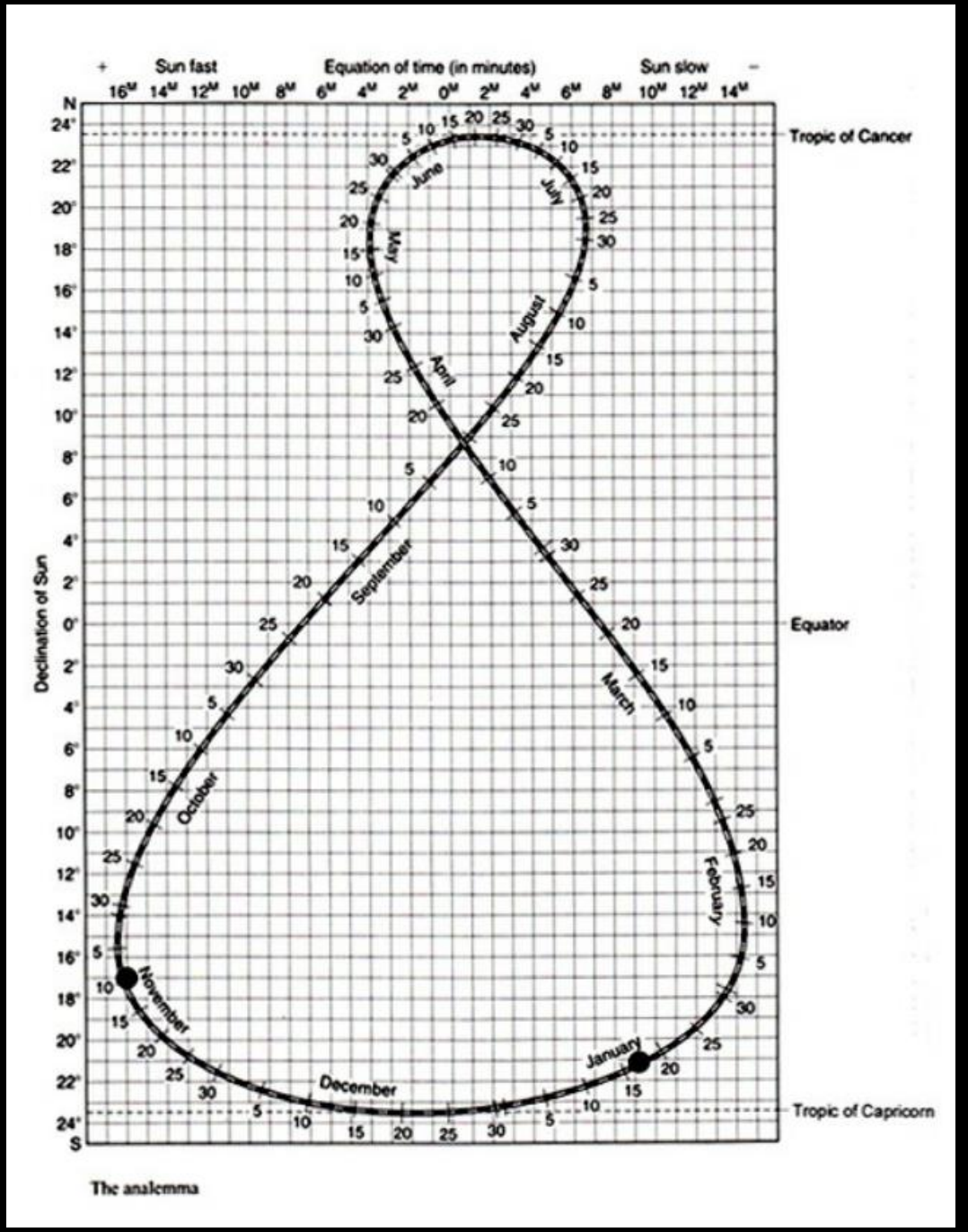
A Sᵉ. Cᵉ. Mᵗⁱᵉ Sᵉ. Mathematico
JOANNE KEPLERO,

Cum ejusdem Cᵉ. Mᵗⁱᵉ privilegio ſpeciali
ANNO æræ Dionyſianæ cIↃ IↃ c IX.

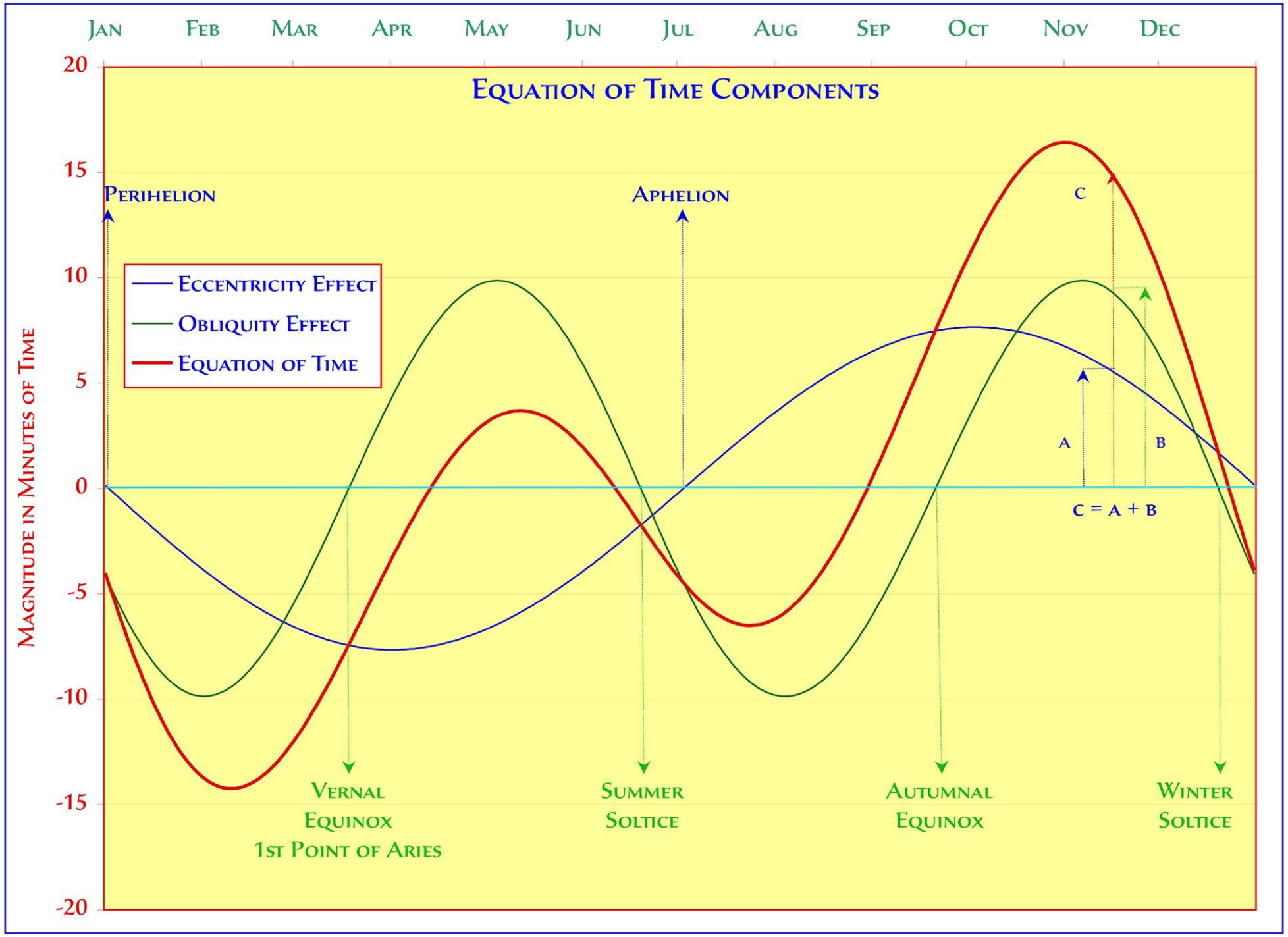
"Astronomia Nova" (1609)

- "Force" from the Sun?
- Planets as free objects, not fixed to spheres
- Strong argument for heliocentric idea
- Preface by Tycho's son-in-law





The analemma


Jan
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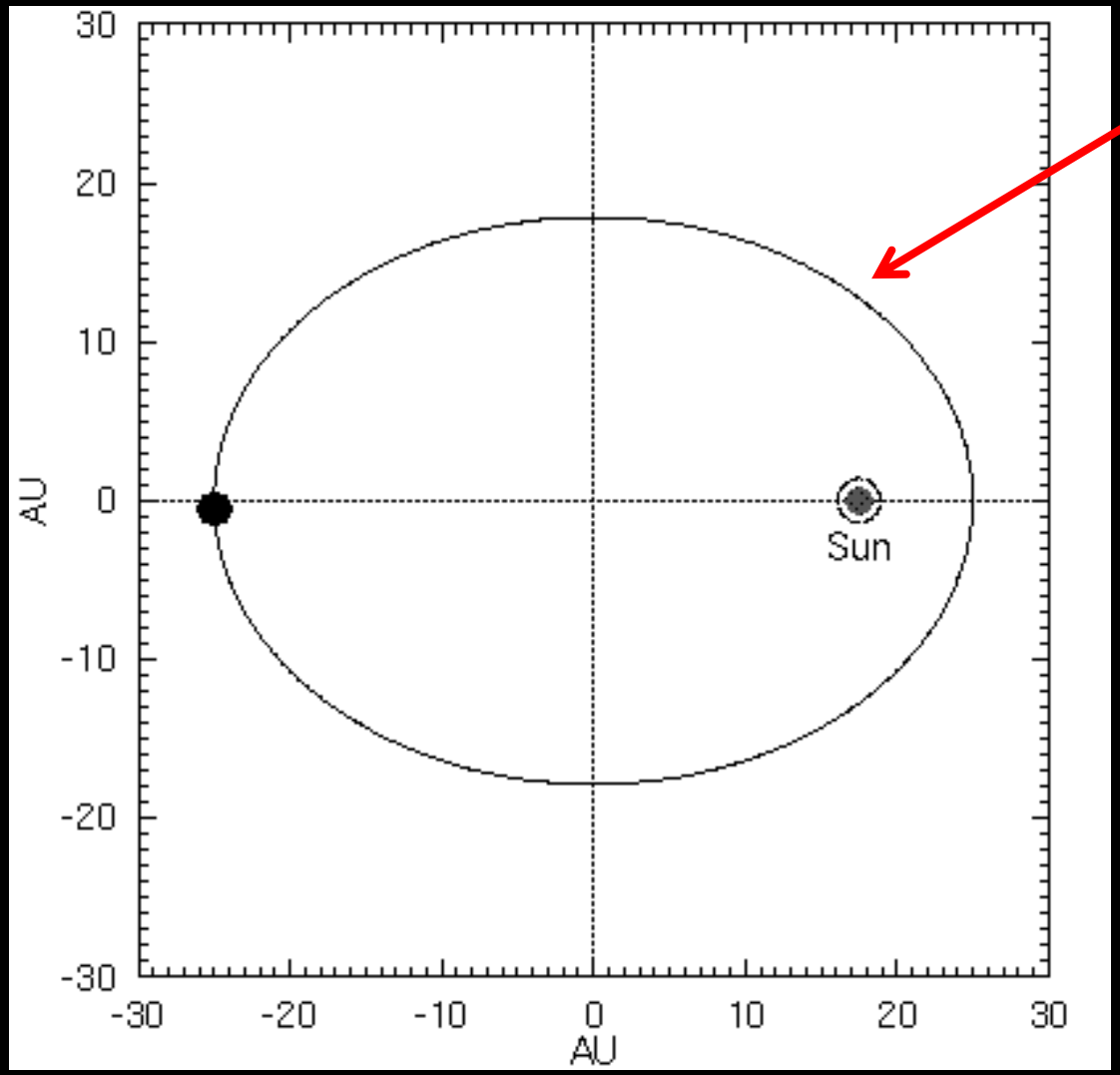
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Equation of Time Components
20
15
10
5
0
-5
-10
-15
-20
Magnitude in Minutes of Time
Perihelion
Aphelion
Eccentricity Effect
Obliquity Effect
Equation of Time
C
A
B
C = A + B
Vernal
Equinox
1st Point of Aries
Summer
Soltice
Autumnal
Equinox
Winter
Soltice

Johannes Kepler

- German math dude
- Universe is simple & mathematical.
- “What makes planets move?”
- Protestant – fled to join Tycho
- Studied Mars data for six years
- Three laws of motion . .

Kepler's Laws

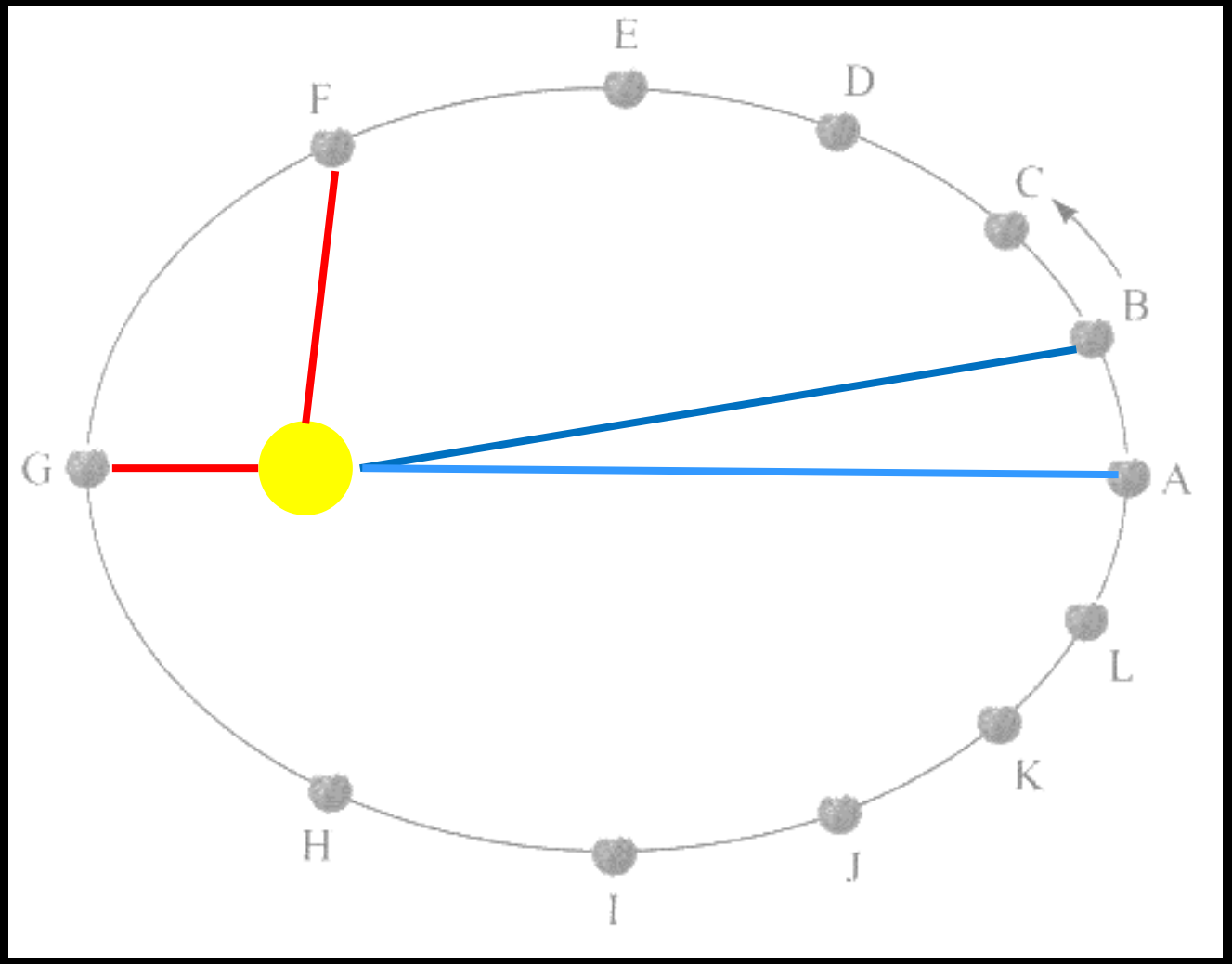


1. Orbits are ellipses with Sun at one focus

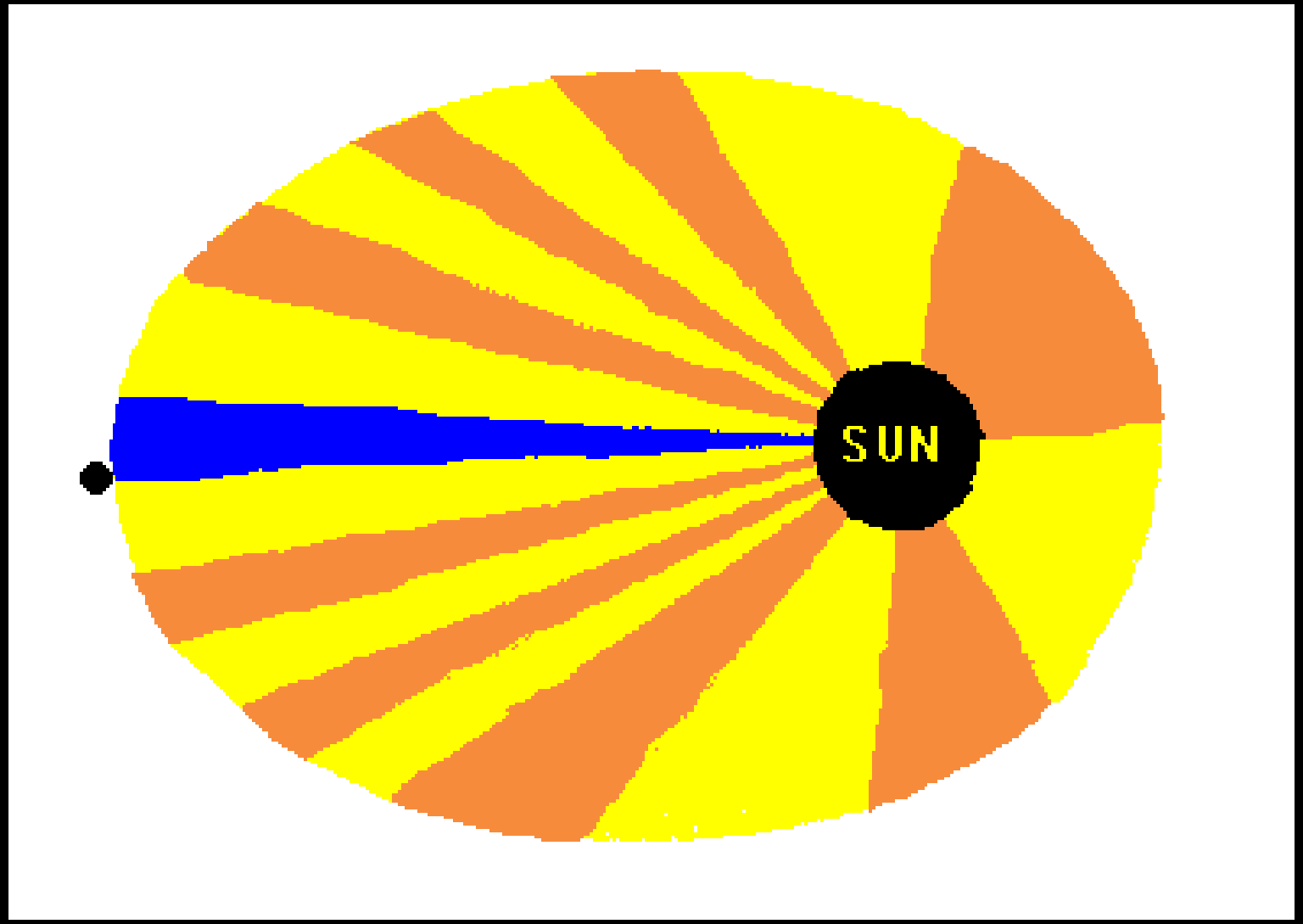
2. "Equal Areas in equal times" (speeds)

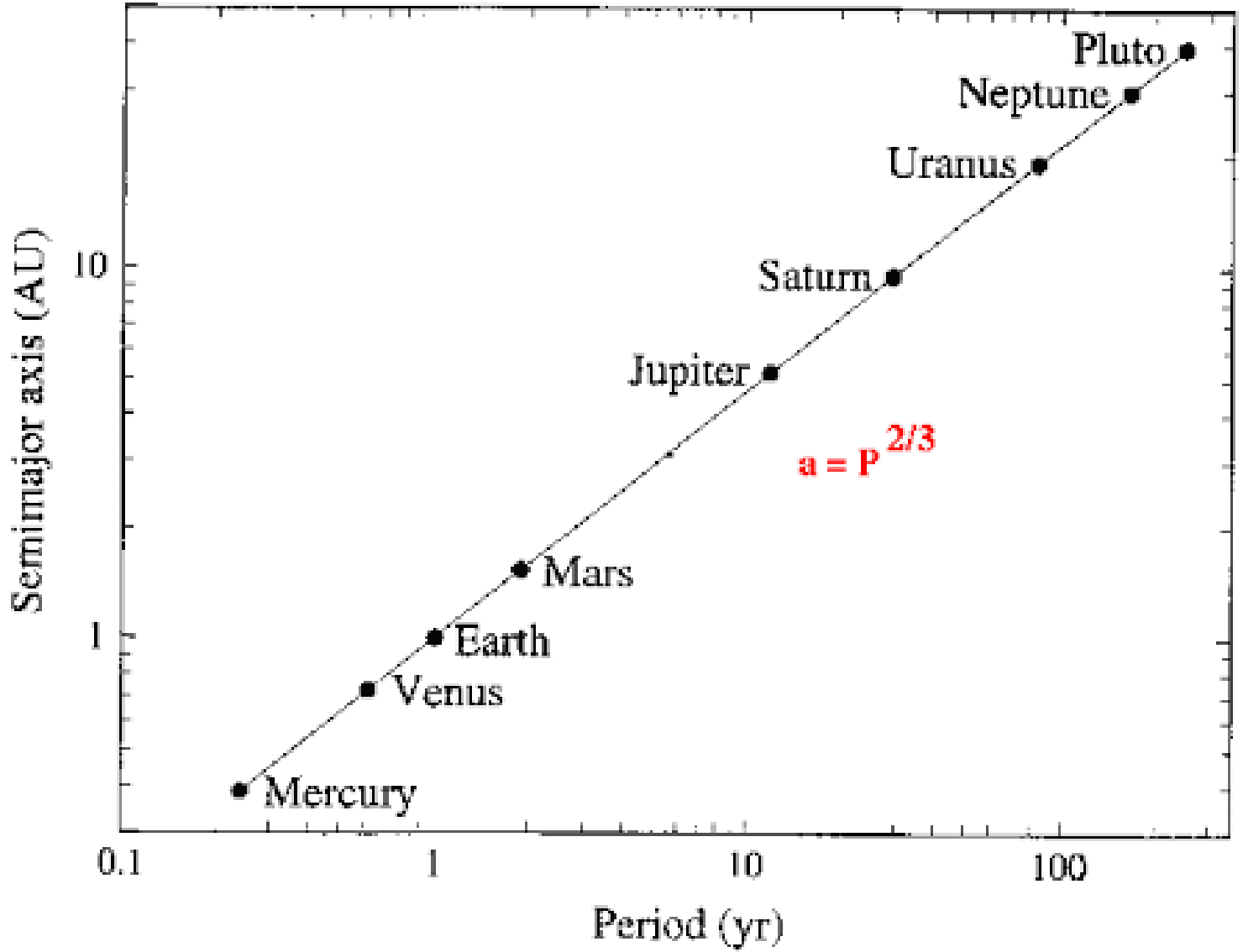
3. Rev. period related to distance

Planet orbits . . . .



Kepler's 2nd Law





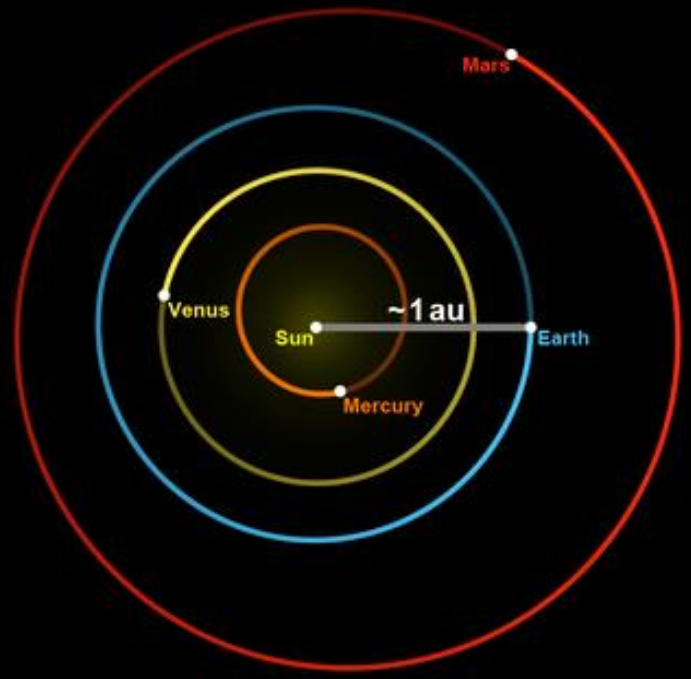
$$T^2 = \frac{4\pi^2}{G(M_1 + M_2)} a^3$$

$T^2=a^3$

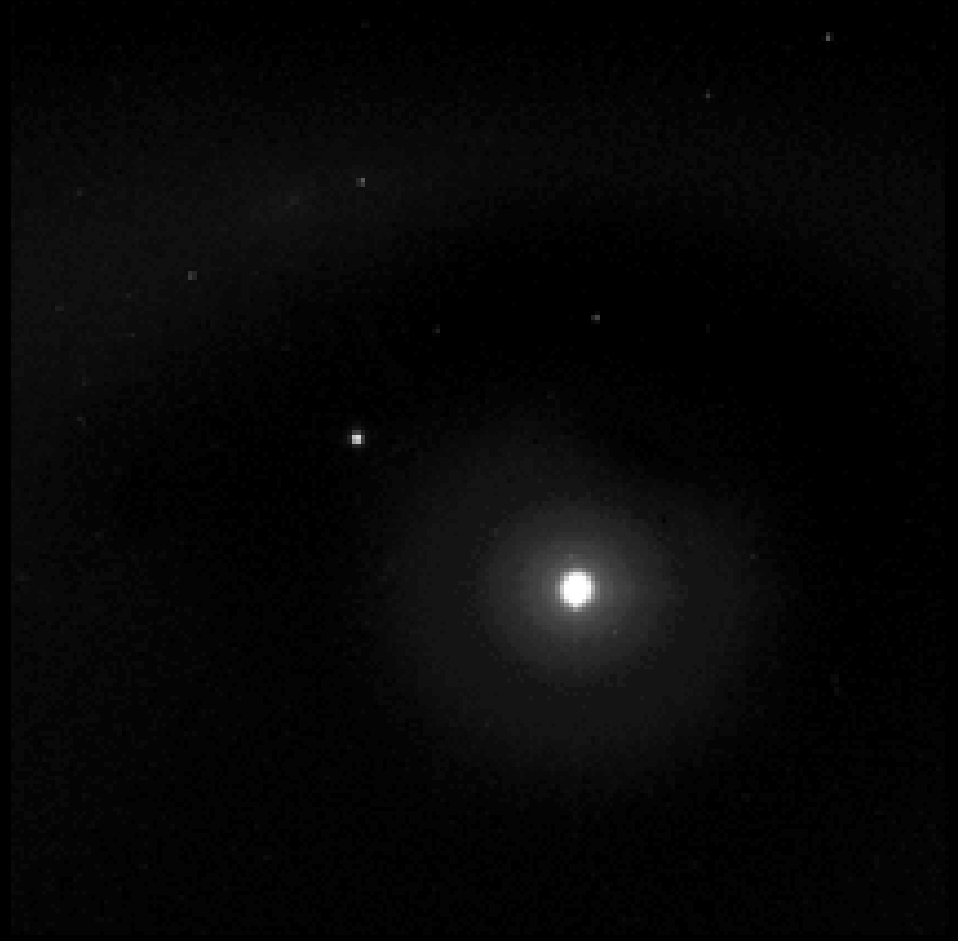
T= Earth years
a= astronomical units (1a= one Earth year)
M= solar mass
G= universal gravitational constant

Solar System Distances (in AU)

- Mercury = 0.39
- Venus = 0.72
- Earth = 1.00
- Mars = 1.52
- Ceres = 2.77
- Jupiter = 5.20
- Saturn = 9.58
- Uranus = 19.20
- Neptune = 30.05
- Pluto = 39.53
- Arrokoth = 44.58
- Eris = 67.96



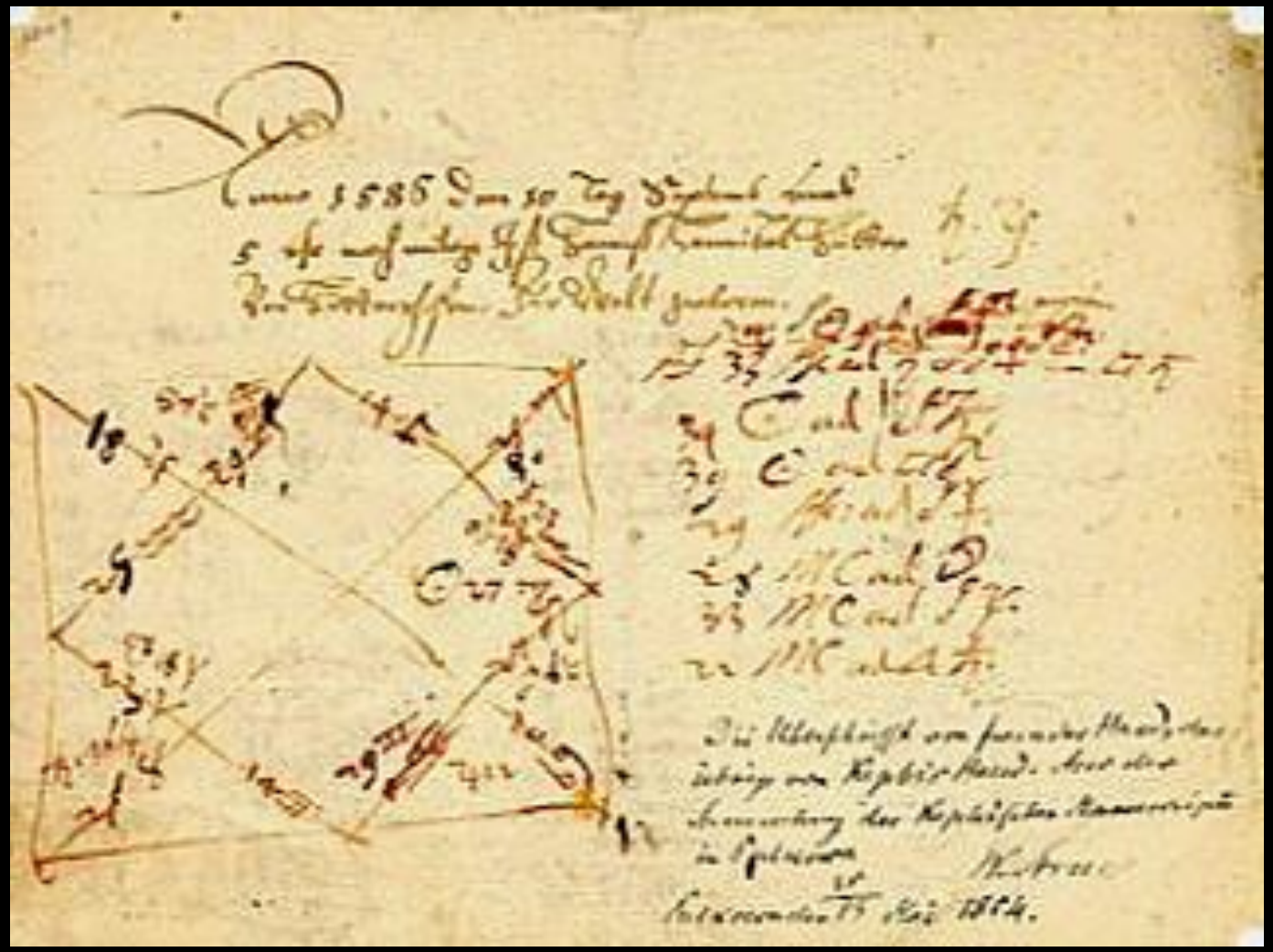
Kepler's 3rd law

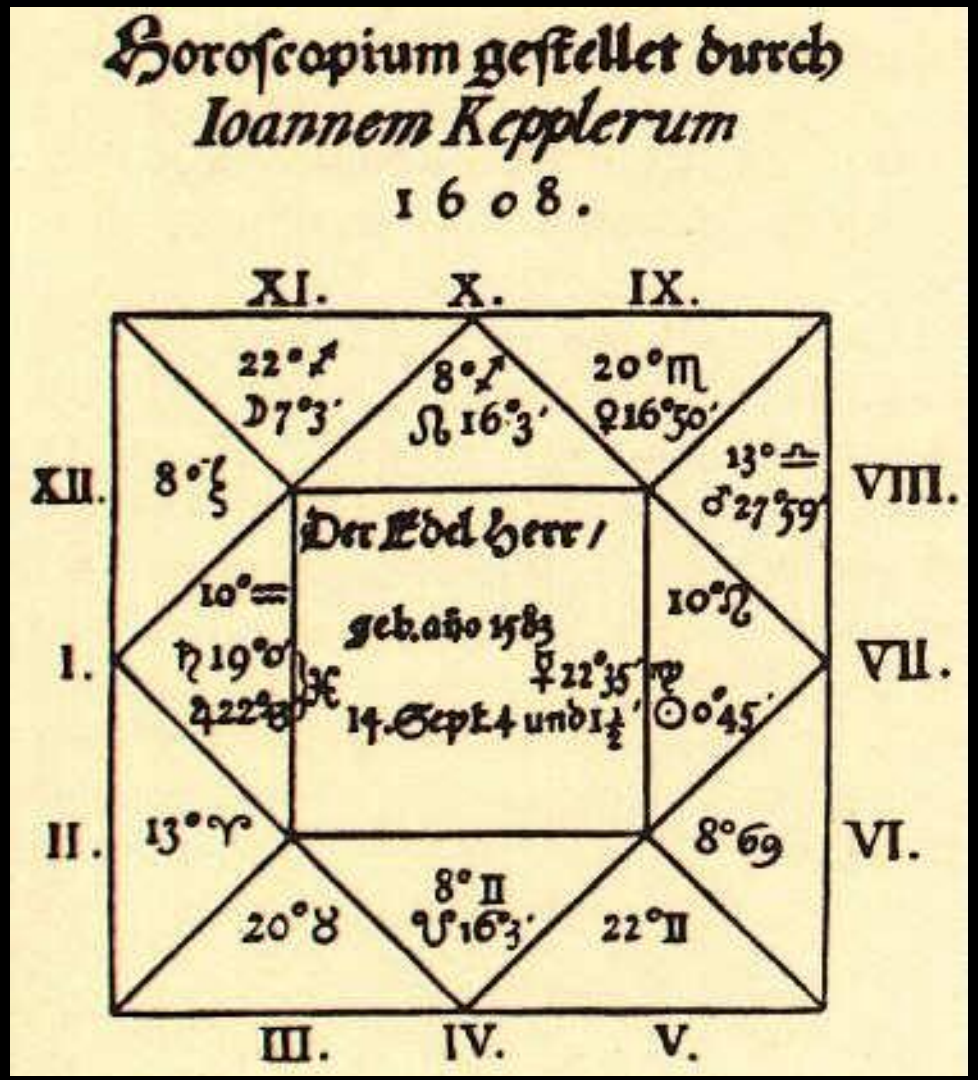


Martian moons . . . .Phobos & Deimos.

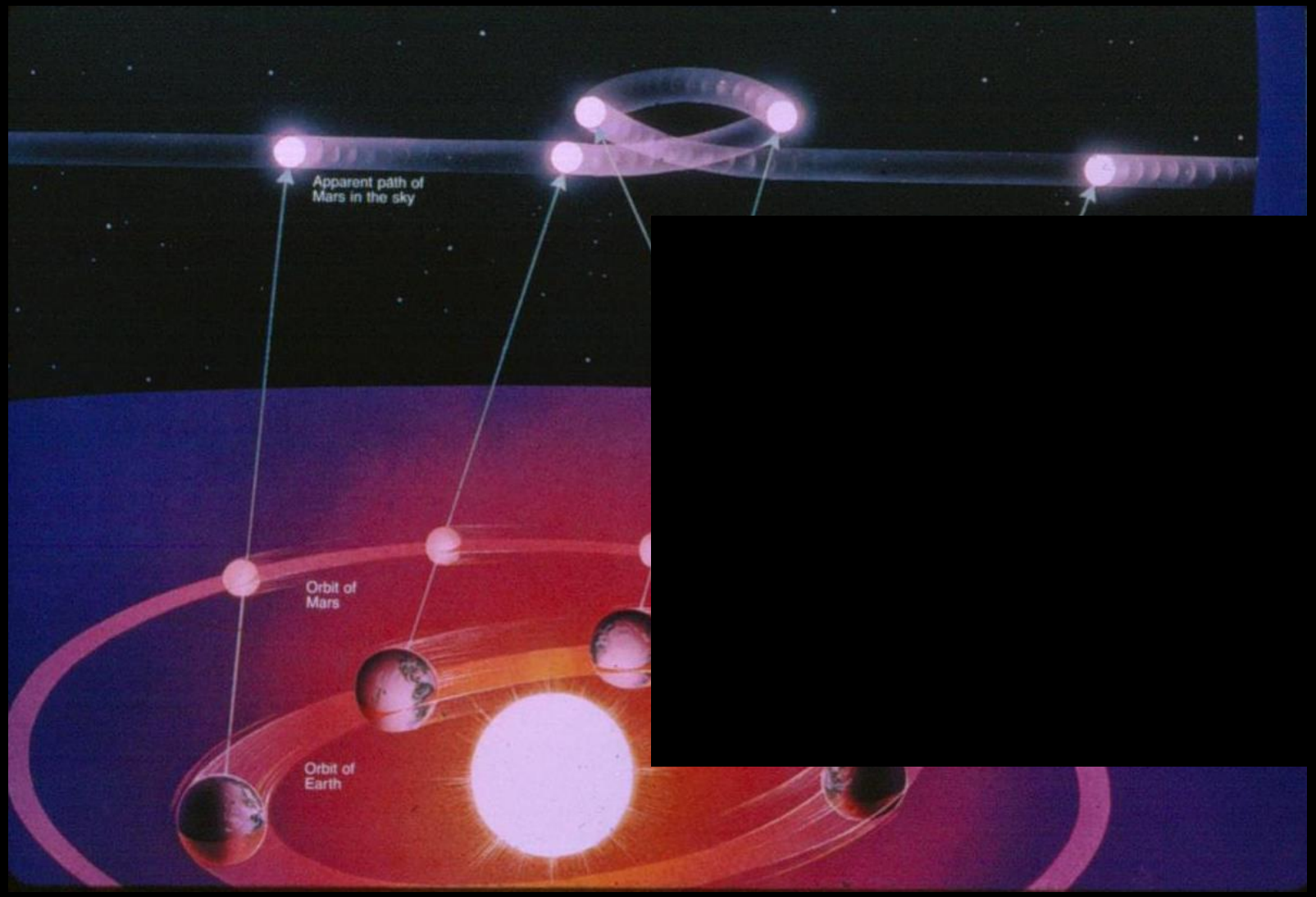
Which one is closer to the Martian surface?

But . . . . Still did horoscopes

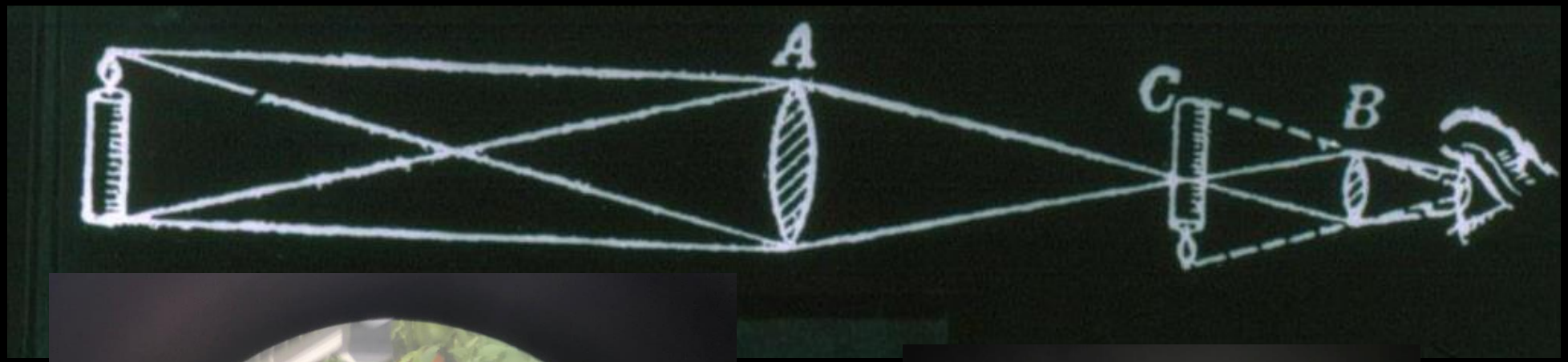


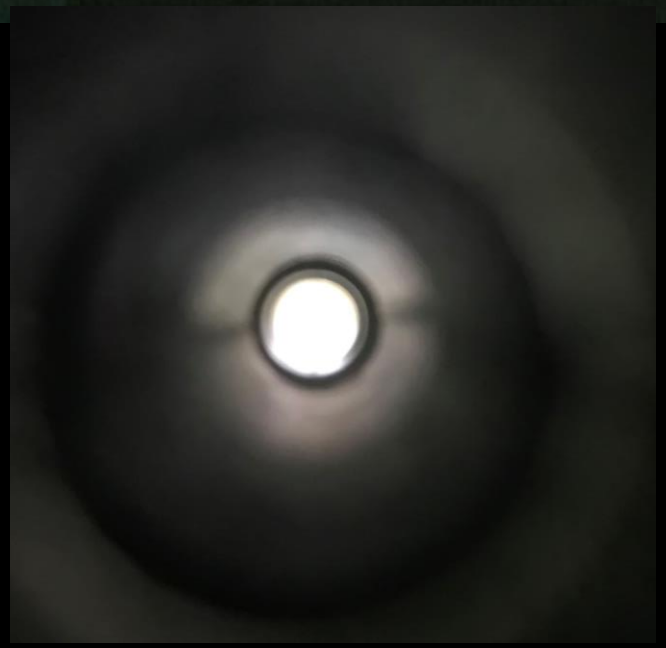


Retrograde motion (heliocentric version)



Kepler’s improvement

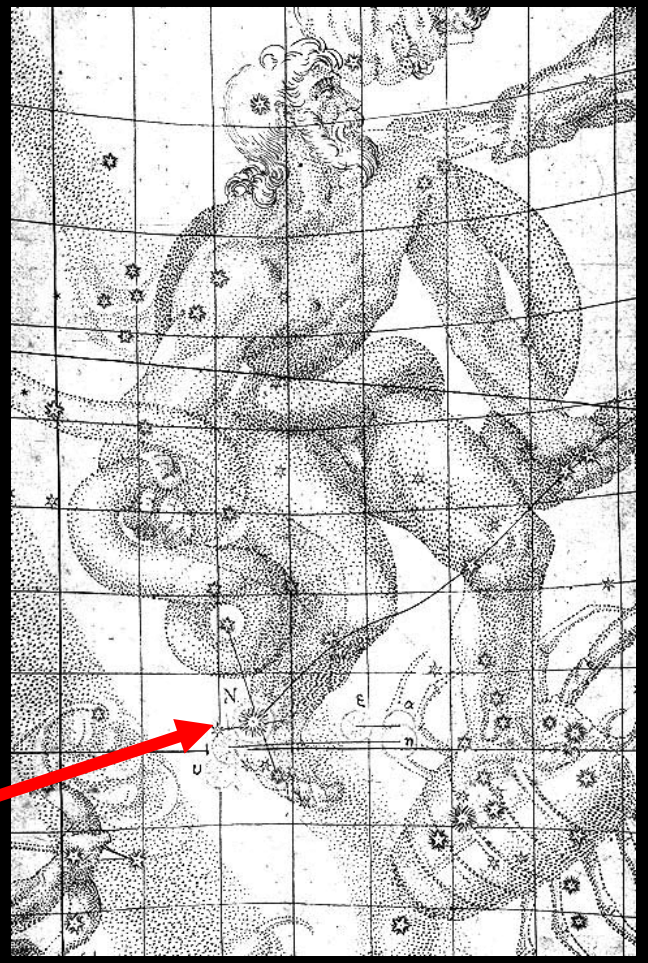


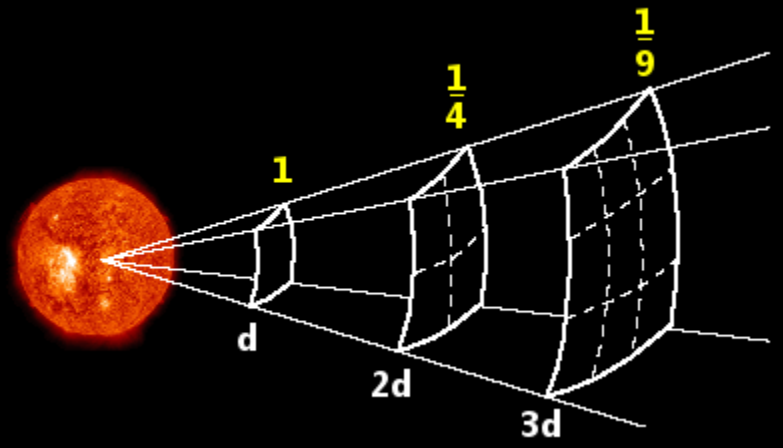



ouseover.html

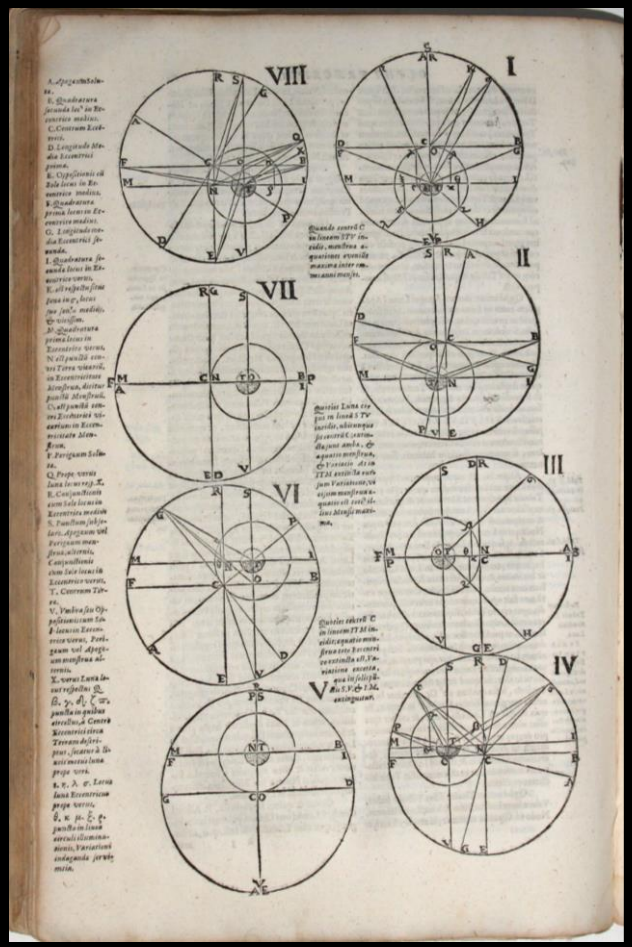
An “active” career!

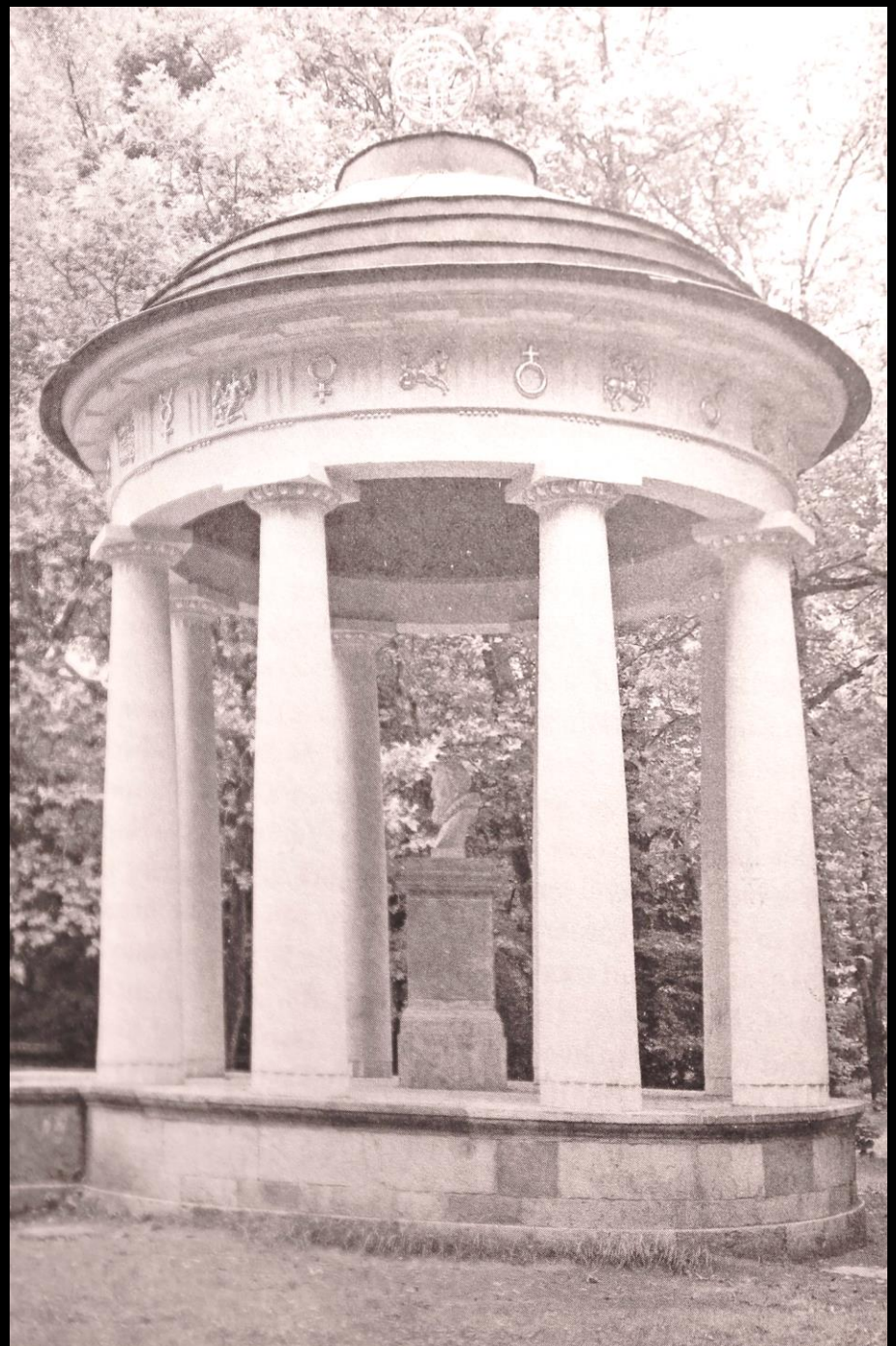
- Inverse square law for light
- Explanation for Earthshine
- Birth of Jesus
- Supernova of 1604
- Halley’s Comet (1607)





Rudolphine Tables (1627)





Death in 1630

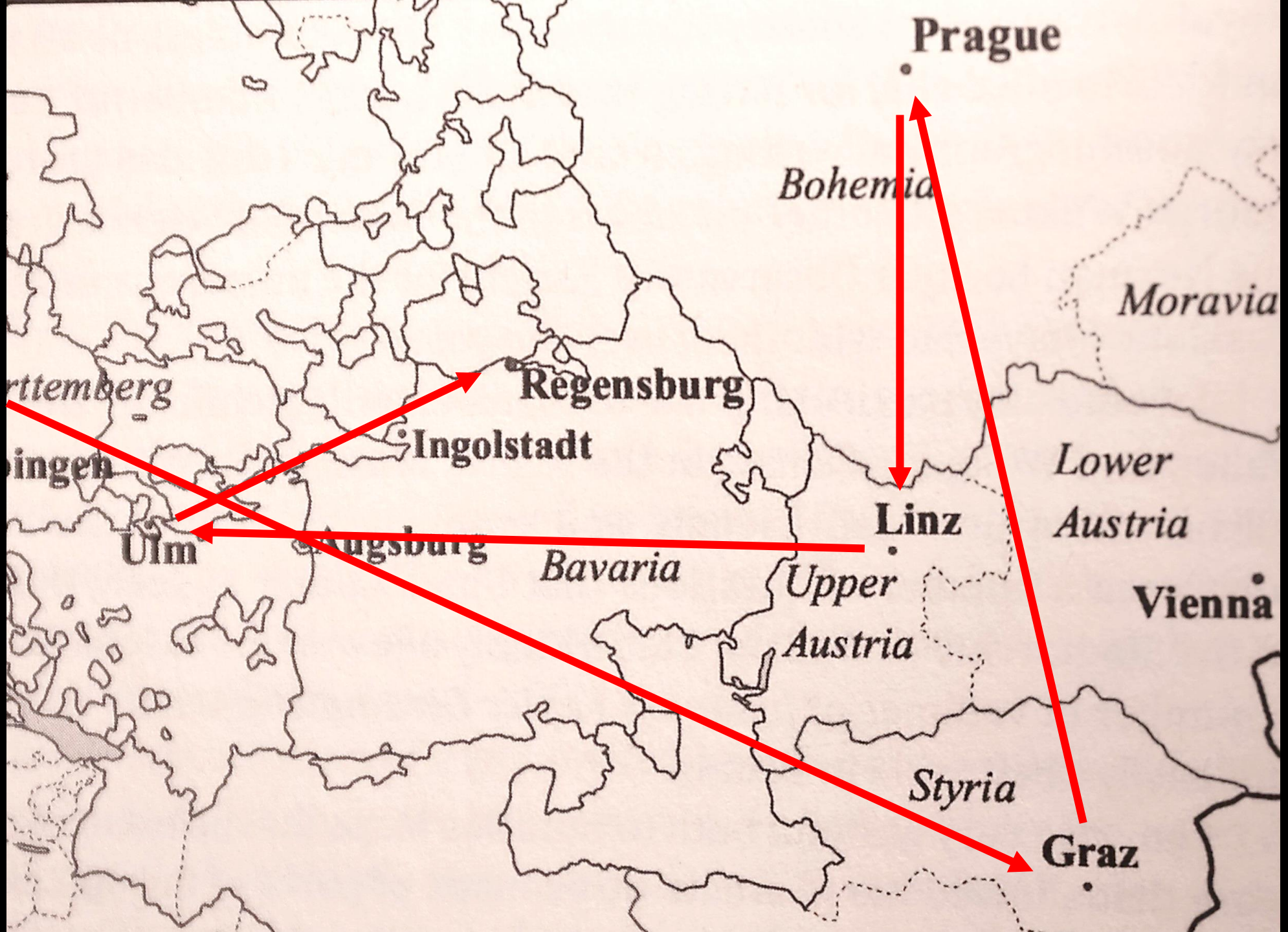
VIR NOBILISSIMVS DOCTISSI-
simq; & Celeberrimus,

Dn: IOHANNES KEPPLERus

TRIVM IMPERATORVM RVDOLPHI II.
MATTHIAE ET FERDINANDI II.
per annos 30. anteà verò Procerum Styriae
ab anno 94. usq; 1600. posteà quoq; Austriaco-
rum Ordinum, ab anno 1612 usq; ad annum
1628. Mathematicus, toti Orbi Christiano per
monumenta publica cognitus, ab omnibus Doctis in-
ter Principes Astronomiae numeratus, qui ma-
nu propria assignatum post se reliquit tale

EPITAPHIVM.

Mensus eram Coelos, nunc Terrae metior


Prague
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Regensburg
Ingolstadt
Linz
Lower
Austria
Ulm
Bavaria
Upper
Austria
Vienna
Styria
Graz

Prague

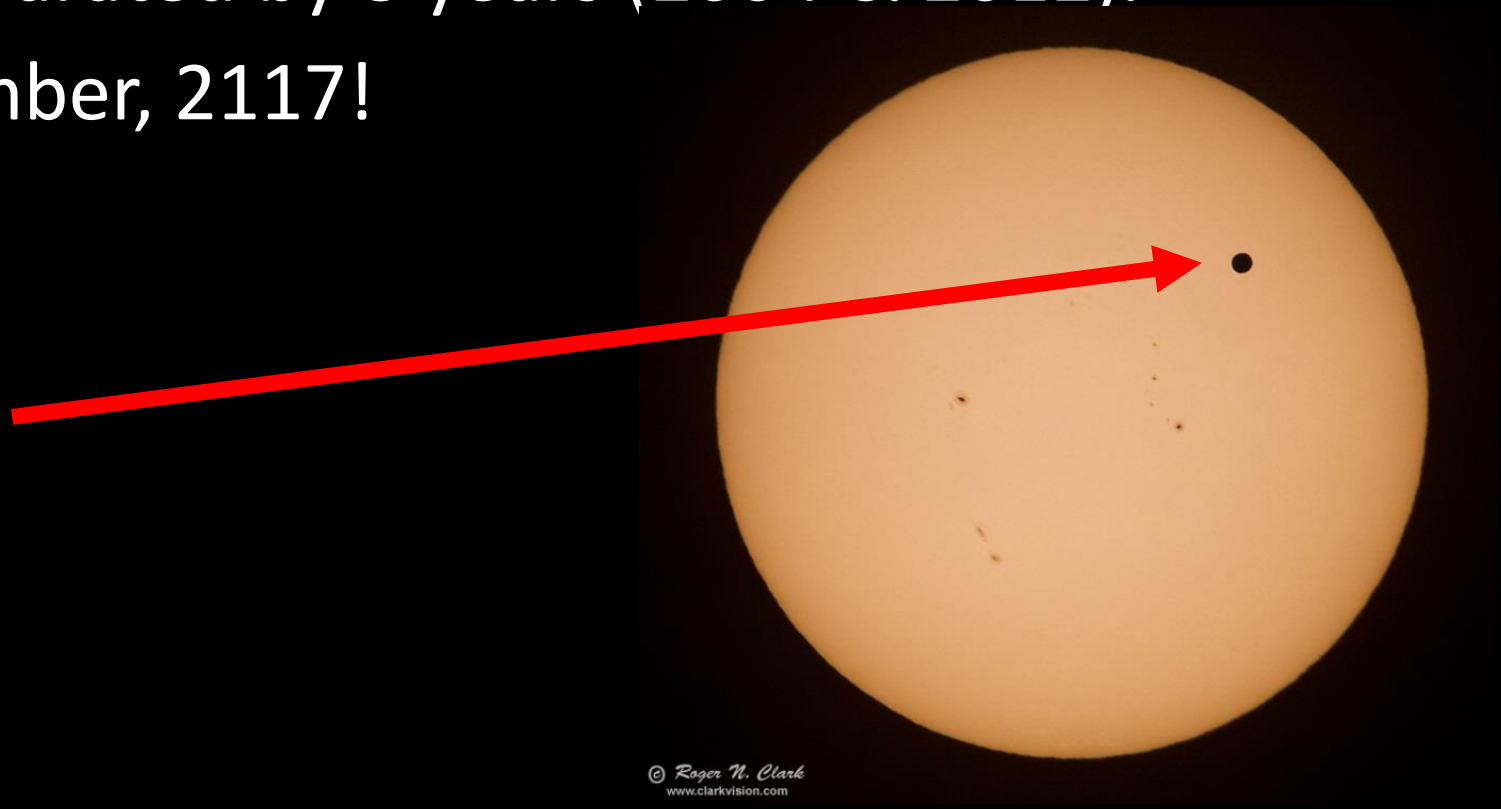
Graz

Weil

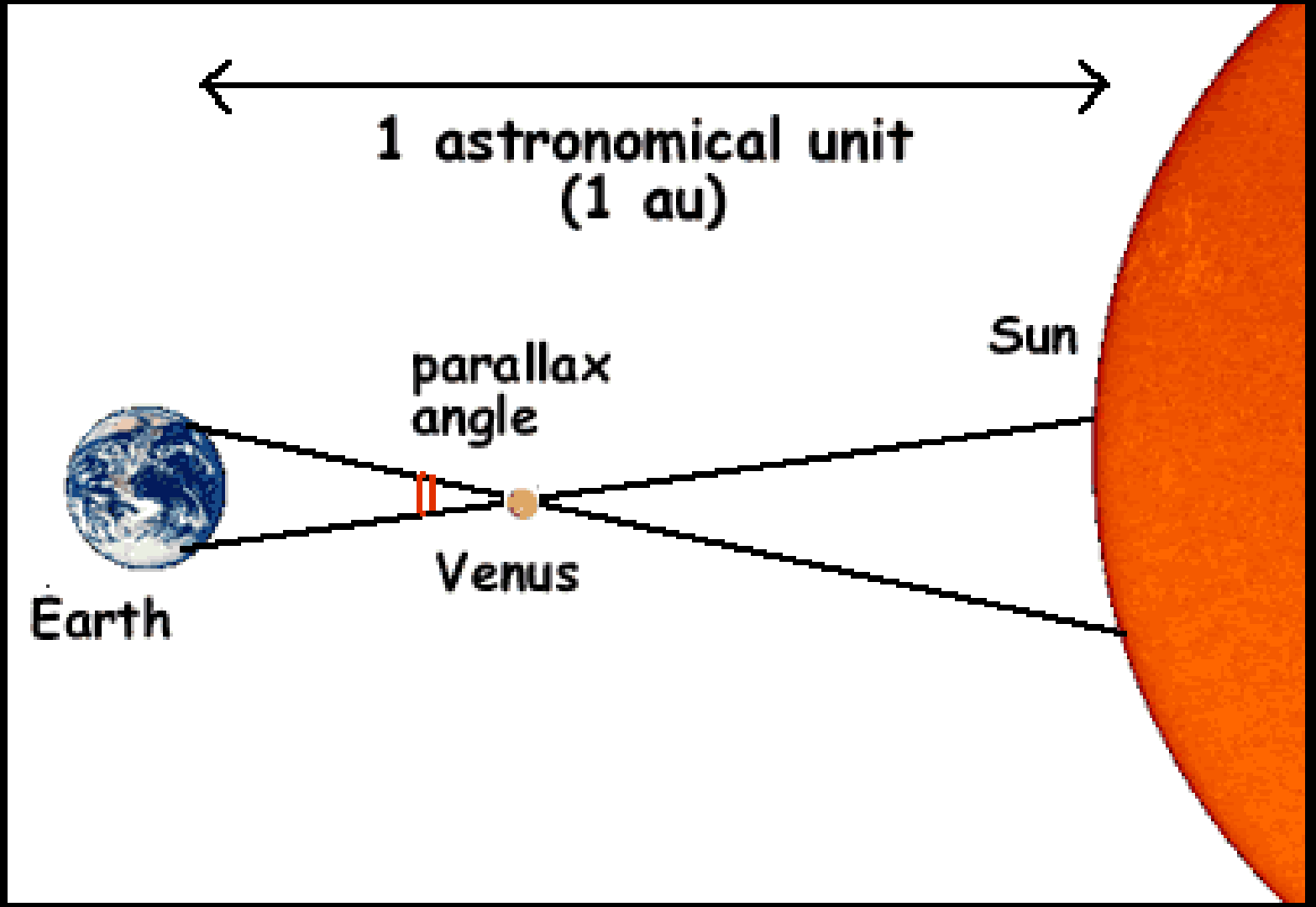
Linz

Transit of Venus

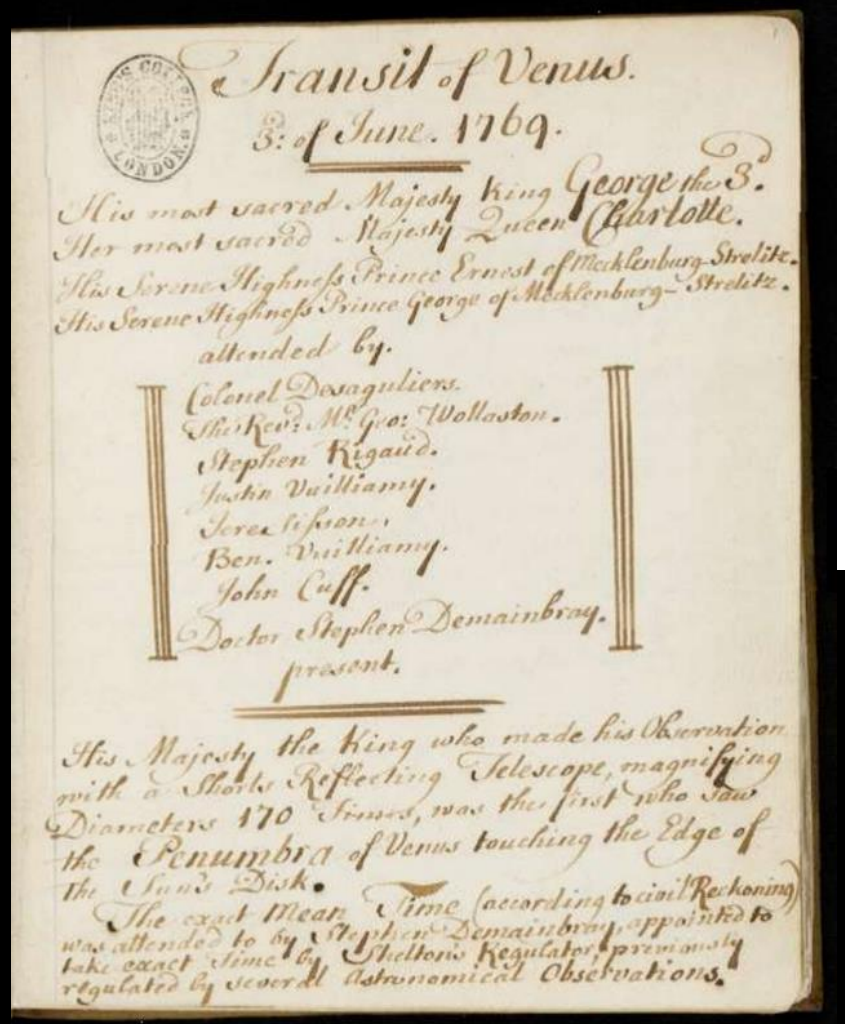
- Only way to accurately determine the “Astronomical Unit”
- Occur in pairs, separated by 8 years (2004 & 2012).
- Next one is December, 2117!



More geometry . . .

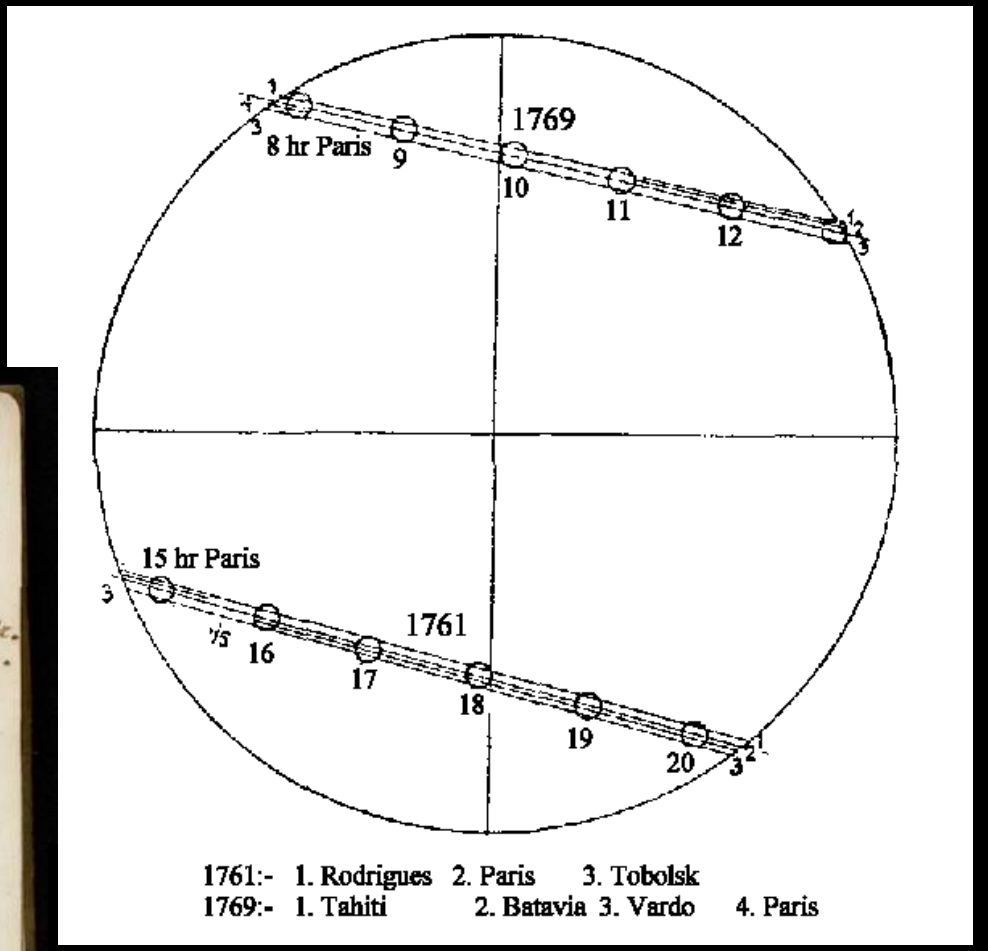


1761 & 1769 . . . .


Transit of Venus.
3: of June. 1769.

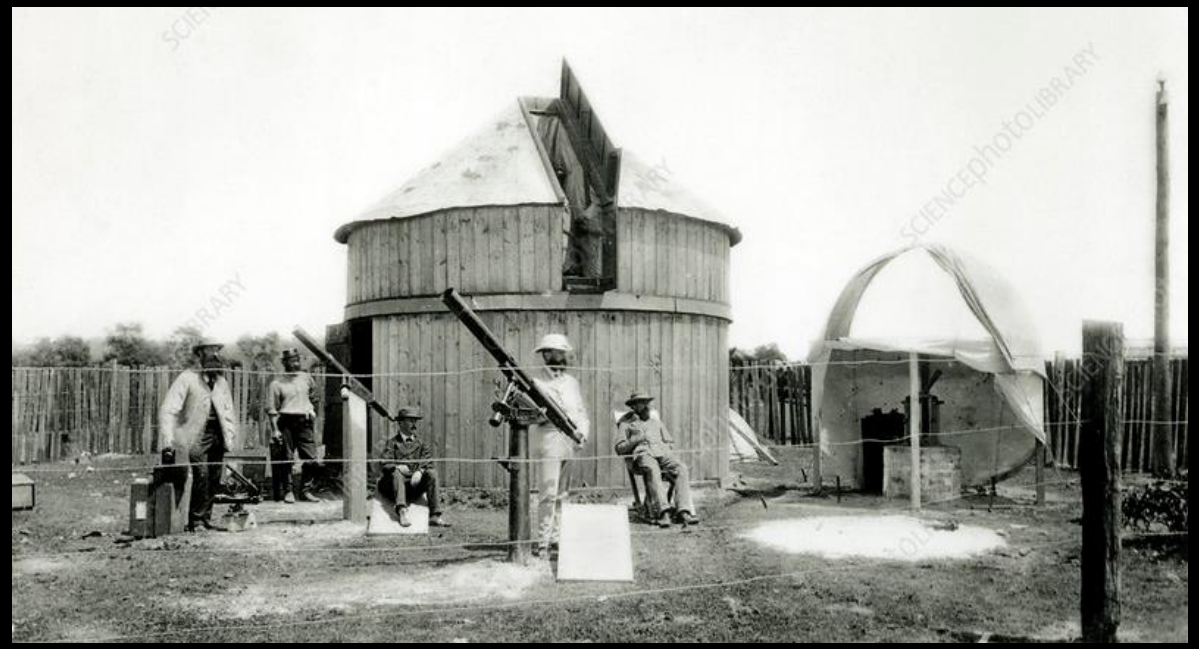
His most sacred Majesty King George the 3.
Her most sacred Majesty Queen Charlotte.
His Serene Highness Prince Ernest of Mecklenburg-Strelitz.
His Serene Highness Prince George of Mecklenburg-Strelitz.
attended by.
Colonel Desaguliers.
The Revd Mr Geo: Wollaston.
Stephen Rigaud.
Justin Vuilliamy.
Jere: Sisson.
Ben. Vuilliamy.
John Cuff.
Doctor Stephen Demainbray.
present.

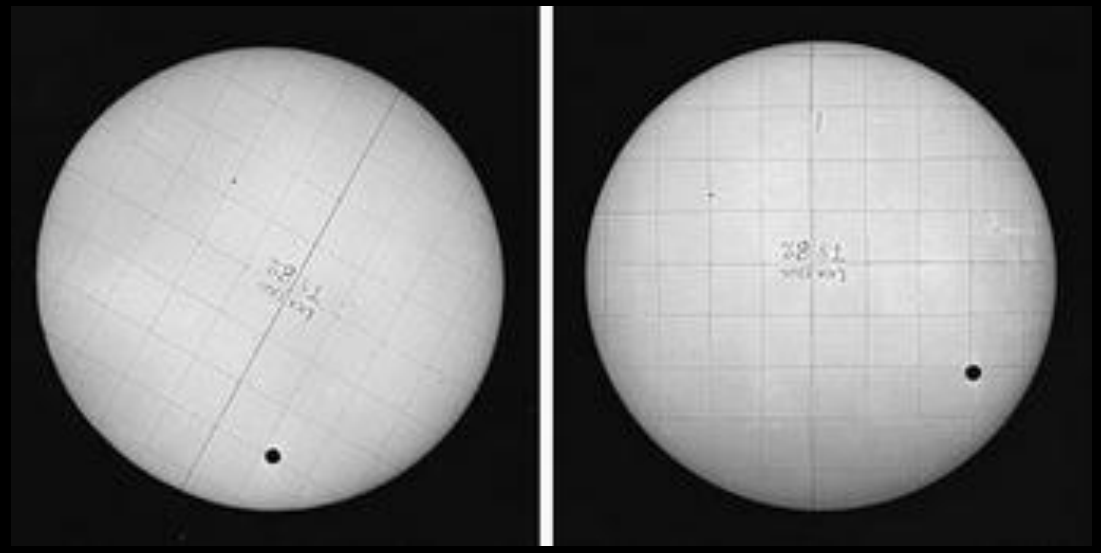
His Majesty the King who made his Observation with a Shorts Reflecting Telescope, magnifying Diameters 170 Times, was the first who saw the Penumbra of Venus touching the Edge of the Sun's Disk.
The exact Mean Time (according to civil Reckoning) was attended to by Stephen Demainbray, appointed to take exact Time by Shelton's Regulator, previously regulated by several Astronomical Observations.



1761:- 1. Rodrigues 2. Paris 3. Tobolsk
1769:- 1. Tahiti 2. Batavia 3. Vardo 4. Paris

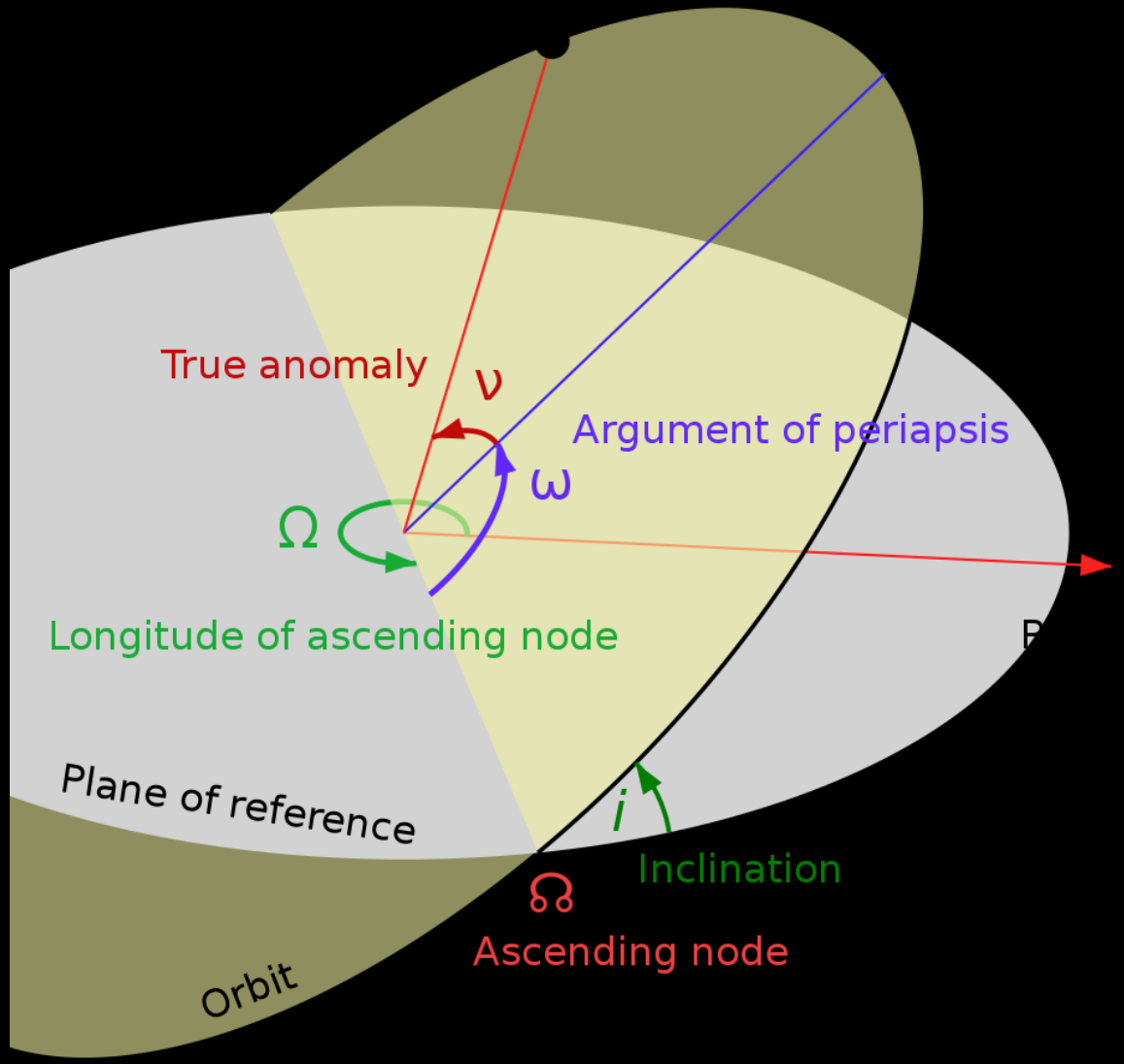
1874 & 1882



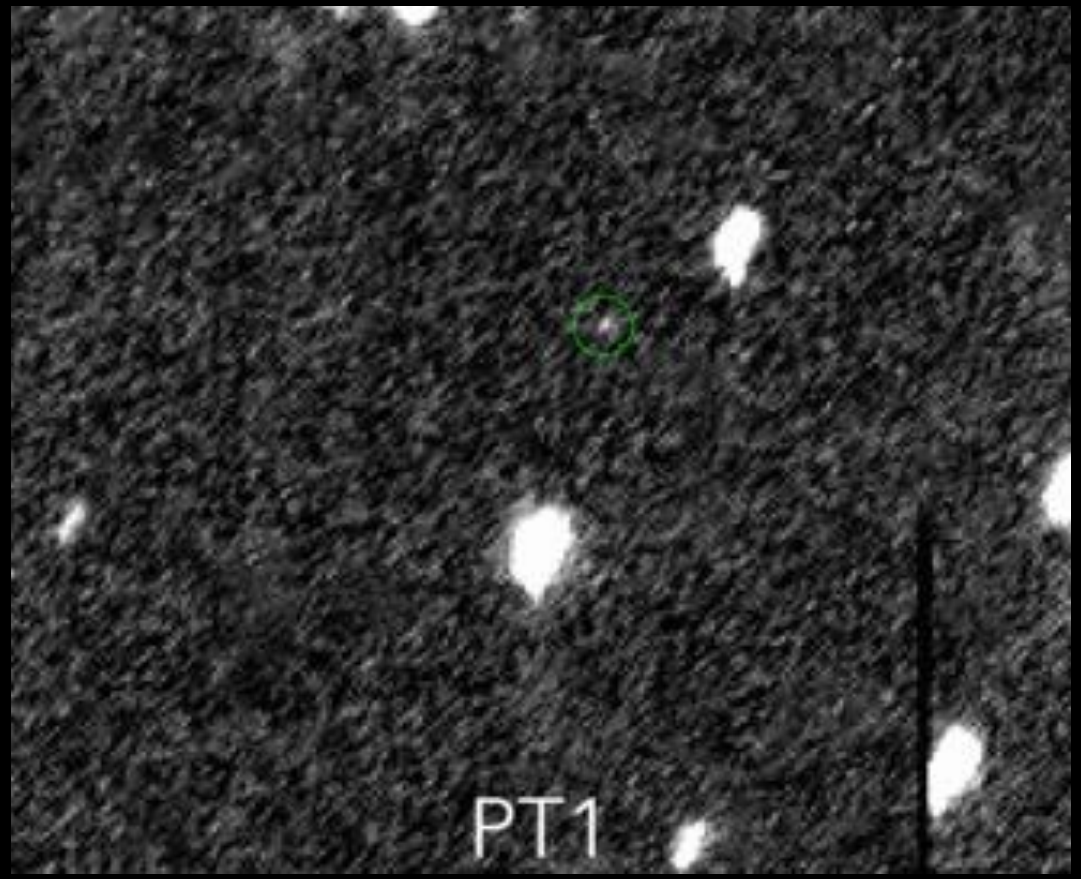


2012 at Parkland

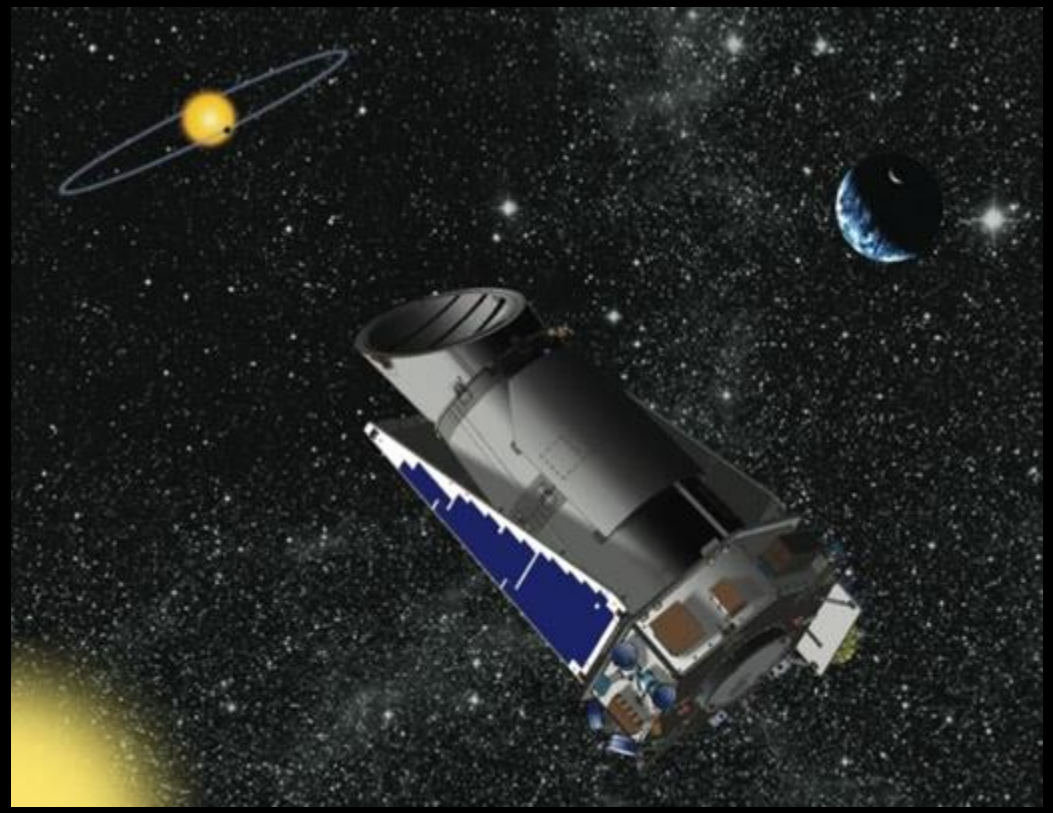
Keplerian orbits

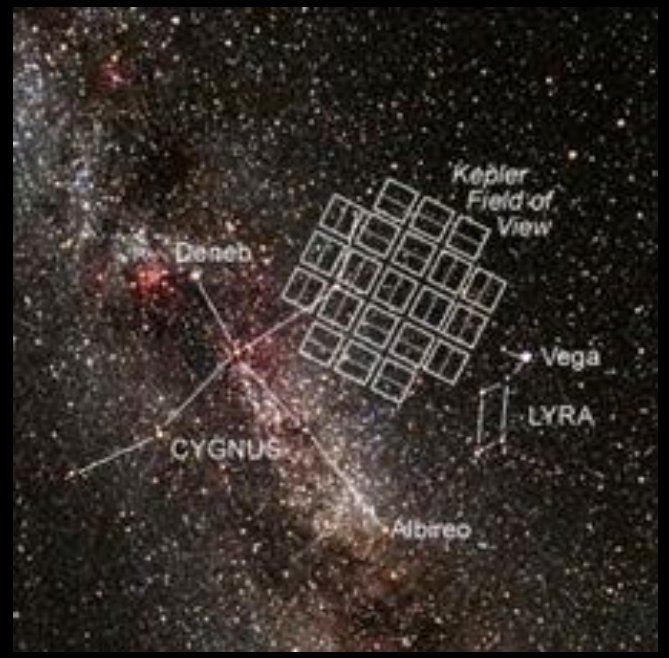


Arrokoth (formally “Ultima Thule)

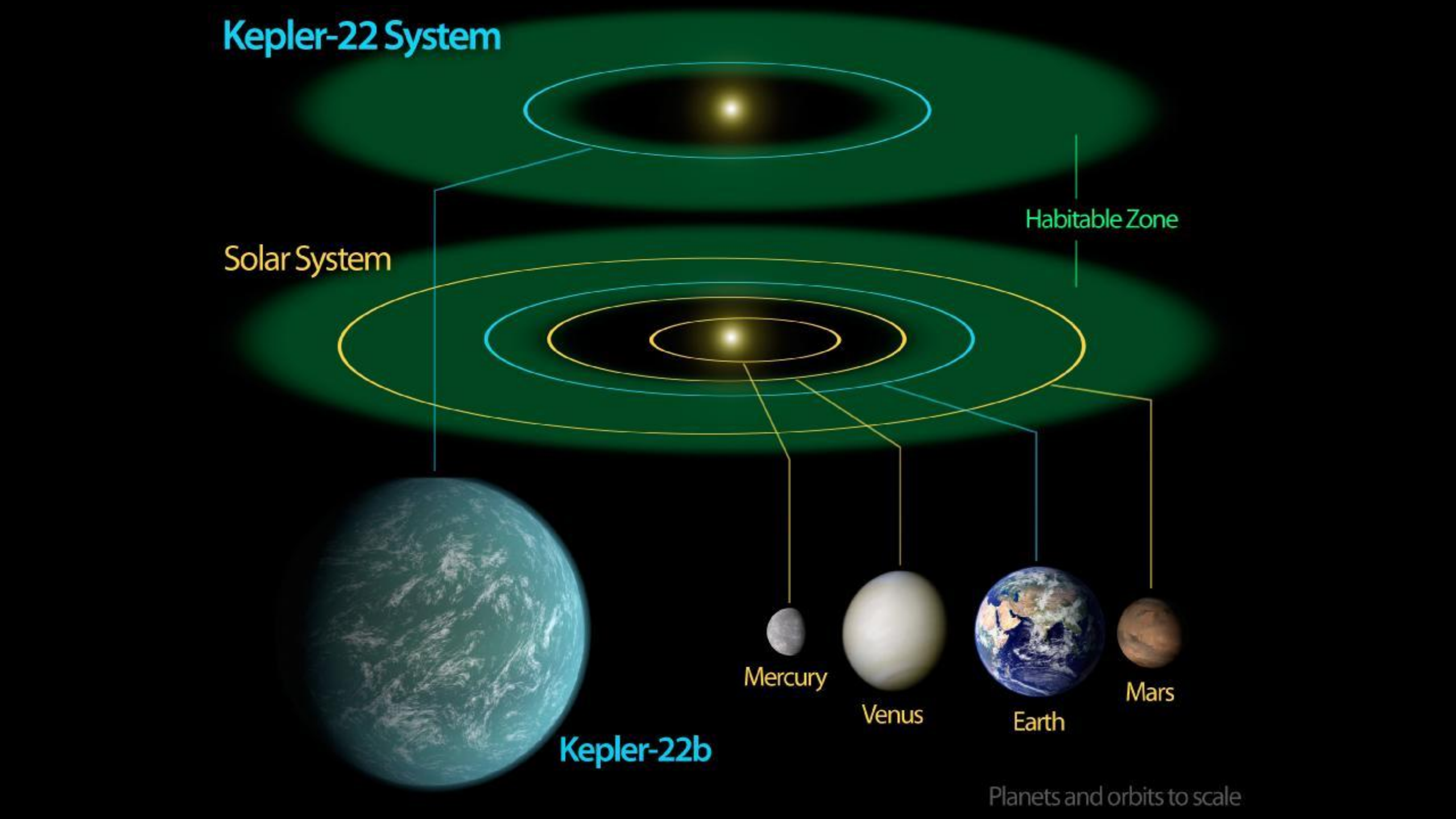



Kepler
A Search for Terrestrial Planets




Kepler
Field of
View
Deneb
Vega
LYRA
CYGNUS
Albireo

2009


Kepler-22 System
Habitable Zone
Solar System
Mercury
Venus
Earth
Mars
Kepler-22b
Planets and orbits to scale


Hotter Stars
Sunlike Stars
Cooler Stars
© NASA

“Earth 2.0??” (Kepler 452b)

Earth 2.0 Found - We Are Not Alone - NASA Announcement - Kepler-452b - ParaNormics

Strong evidence that we are not alone in the Universe has just been announced by NASA. NASA just a few hours ago (July 23rd, 2015 – 4PM UTC) announced they...

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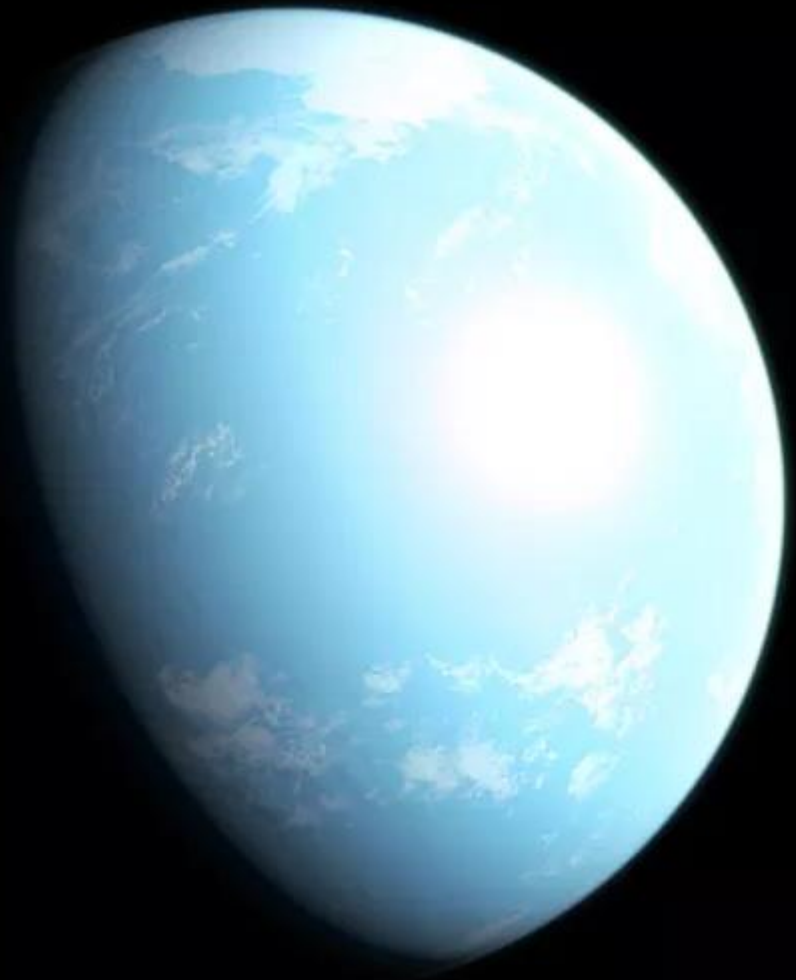
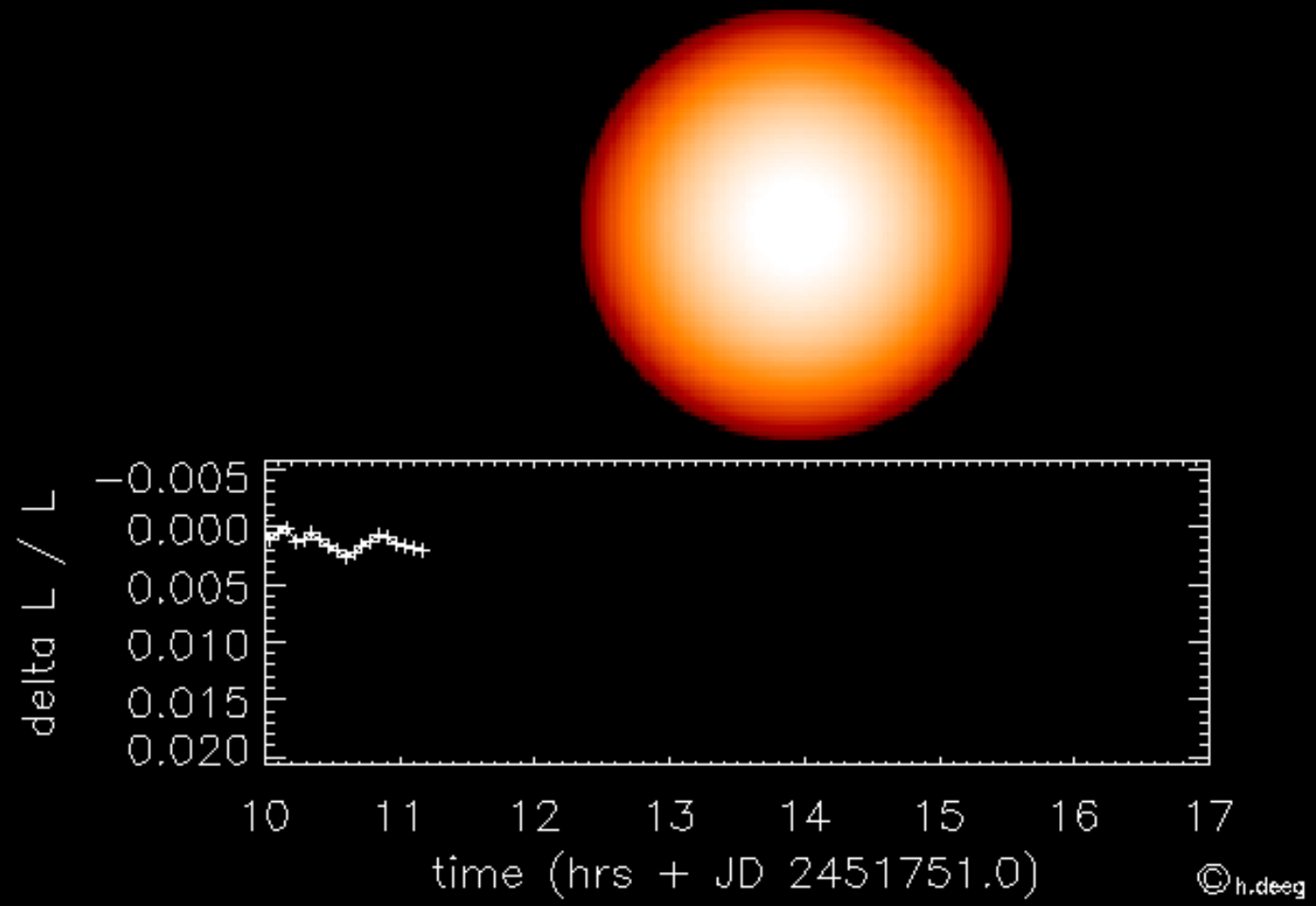
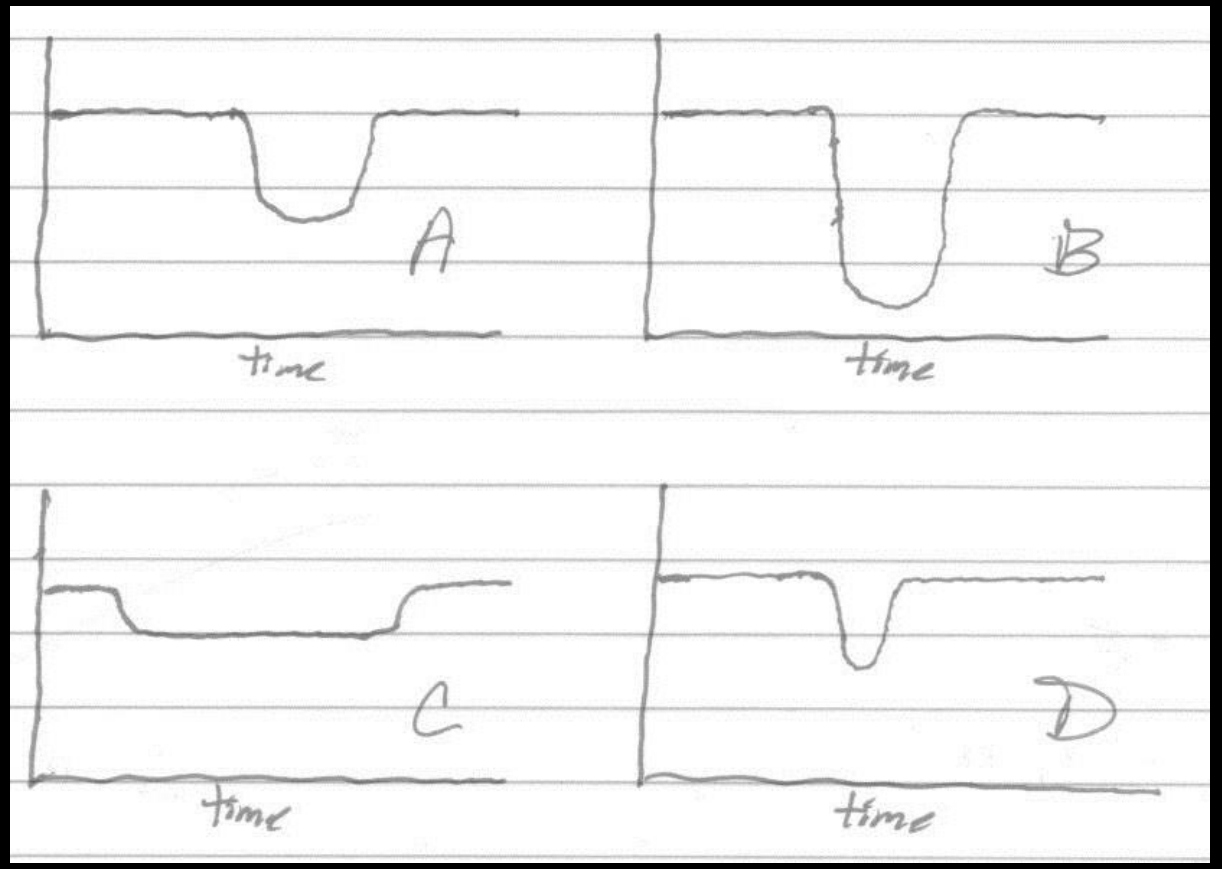


Transits


−0.005
0.000
0.005
0.010
0.015
0.020
delta L / L
10
11
12
13
14
15
16
17
time (hrs + JD 2451751.0)
©h.deeg

What do you think?



1. **Which star system has the largest planet?**
2. **Which planet moves the fastest?**
3. **Which planet is farthest from the star?**

James Webb Space Telescope