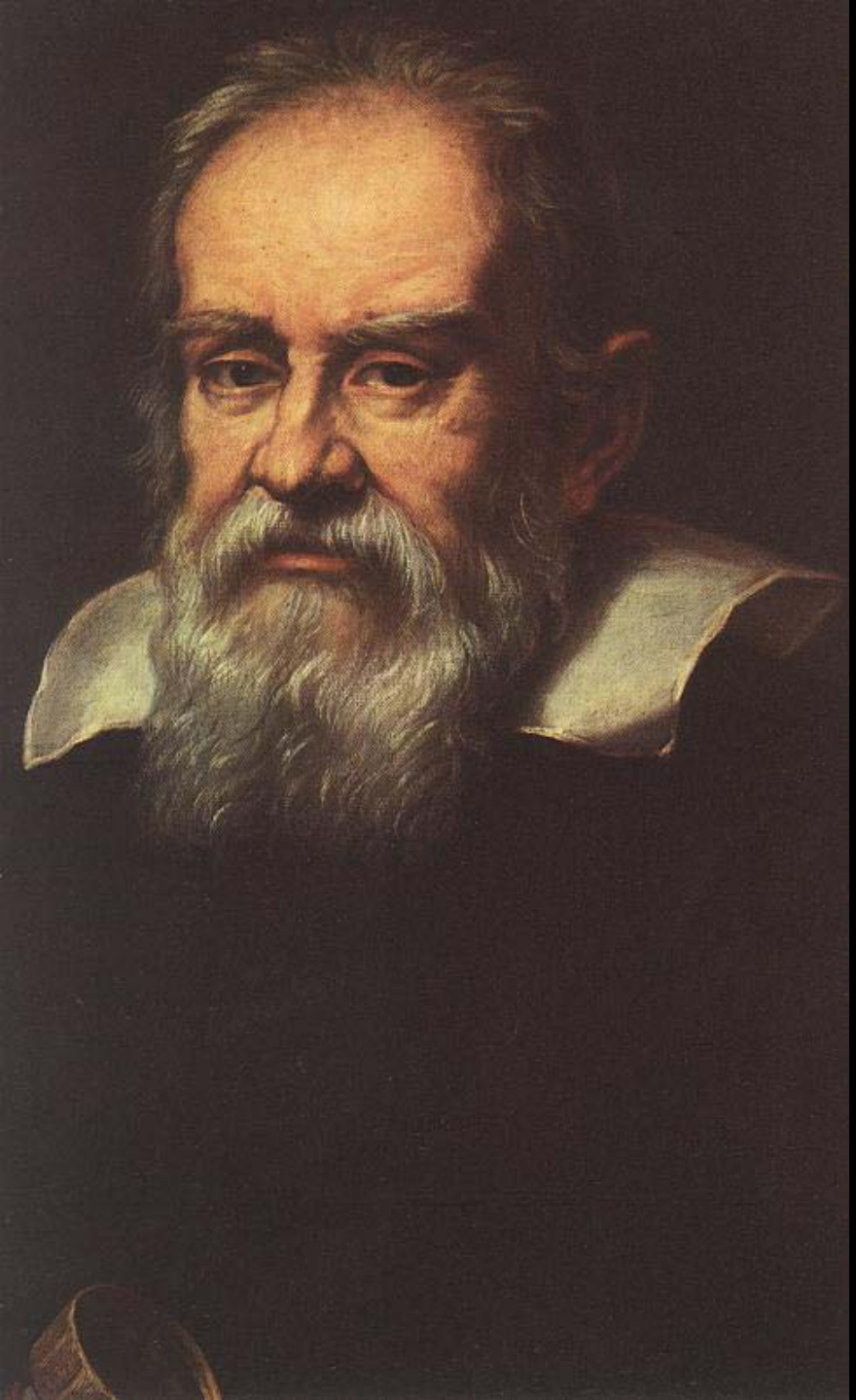


Models
Lecture 3

Galileo Galilei
1564 – 1642
by
Justus Sustermans
Palazzo Pitti
Firenze

Rocky Kolb Productions Presents

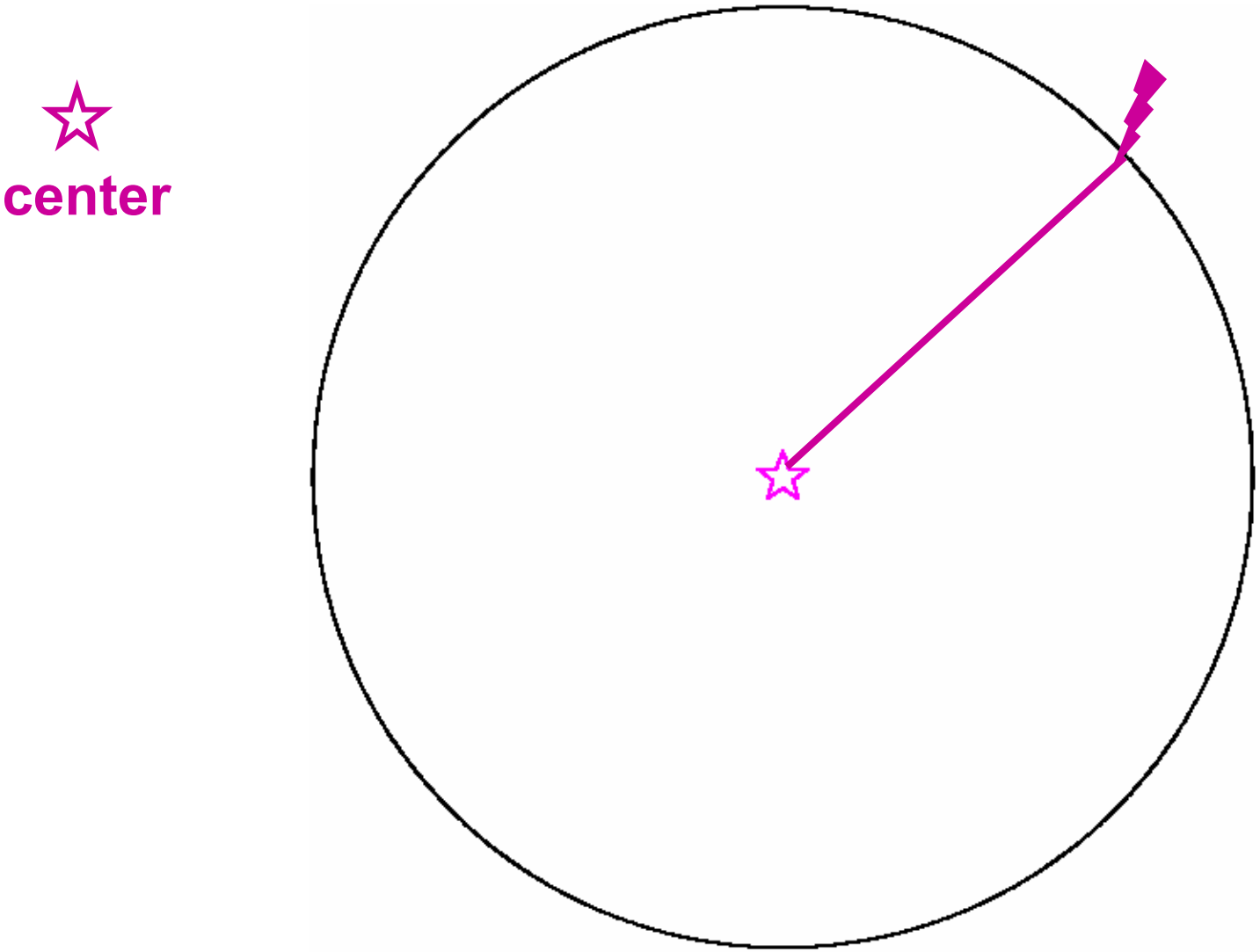
The Dialogue Concerning the Two Chief World Systems

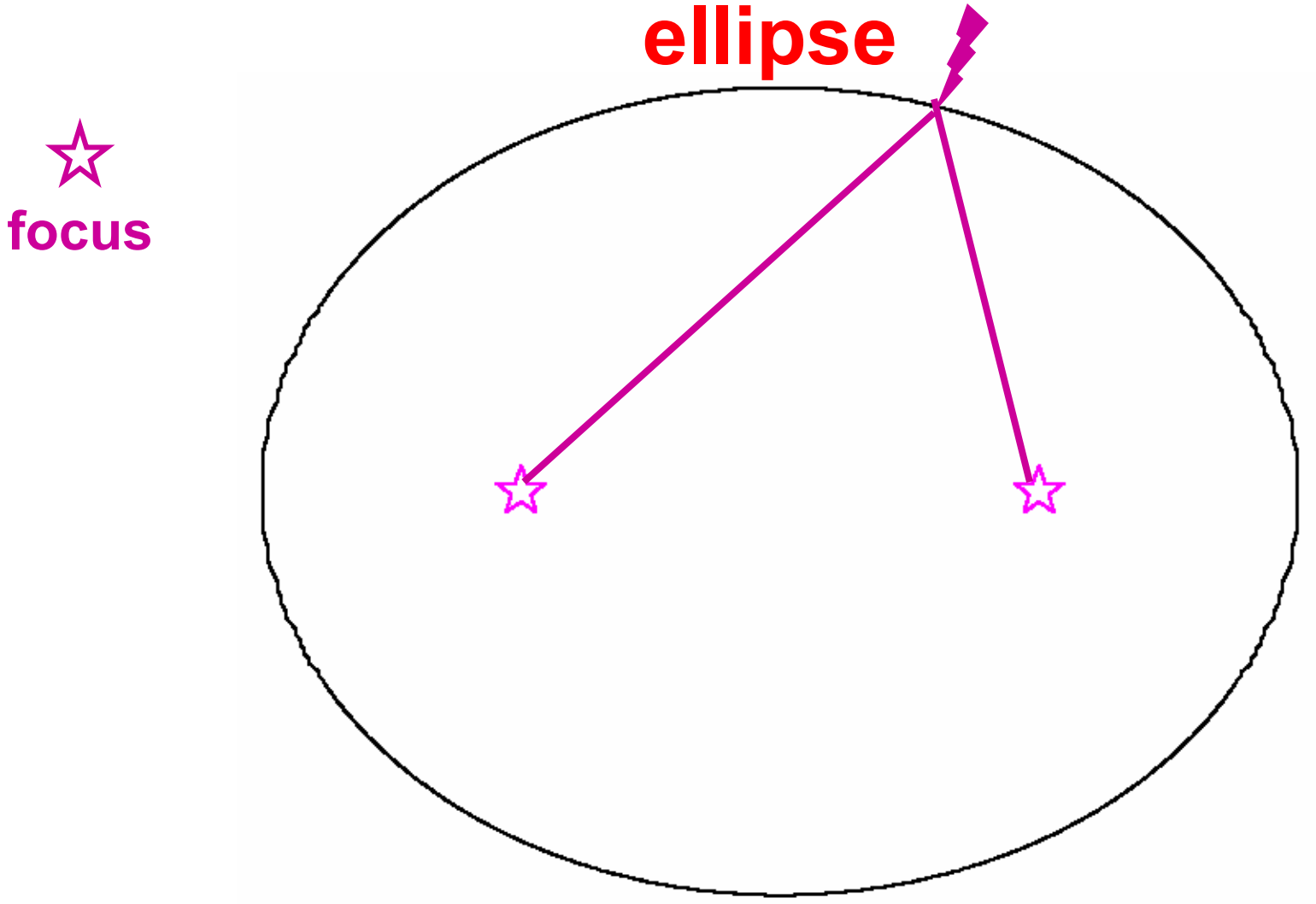
April 11, 2006

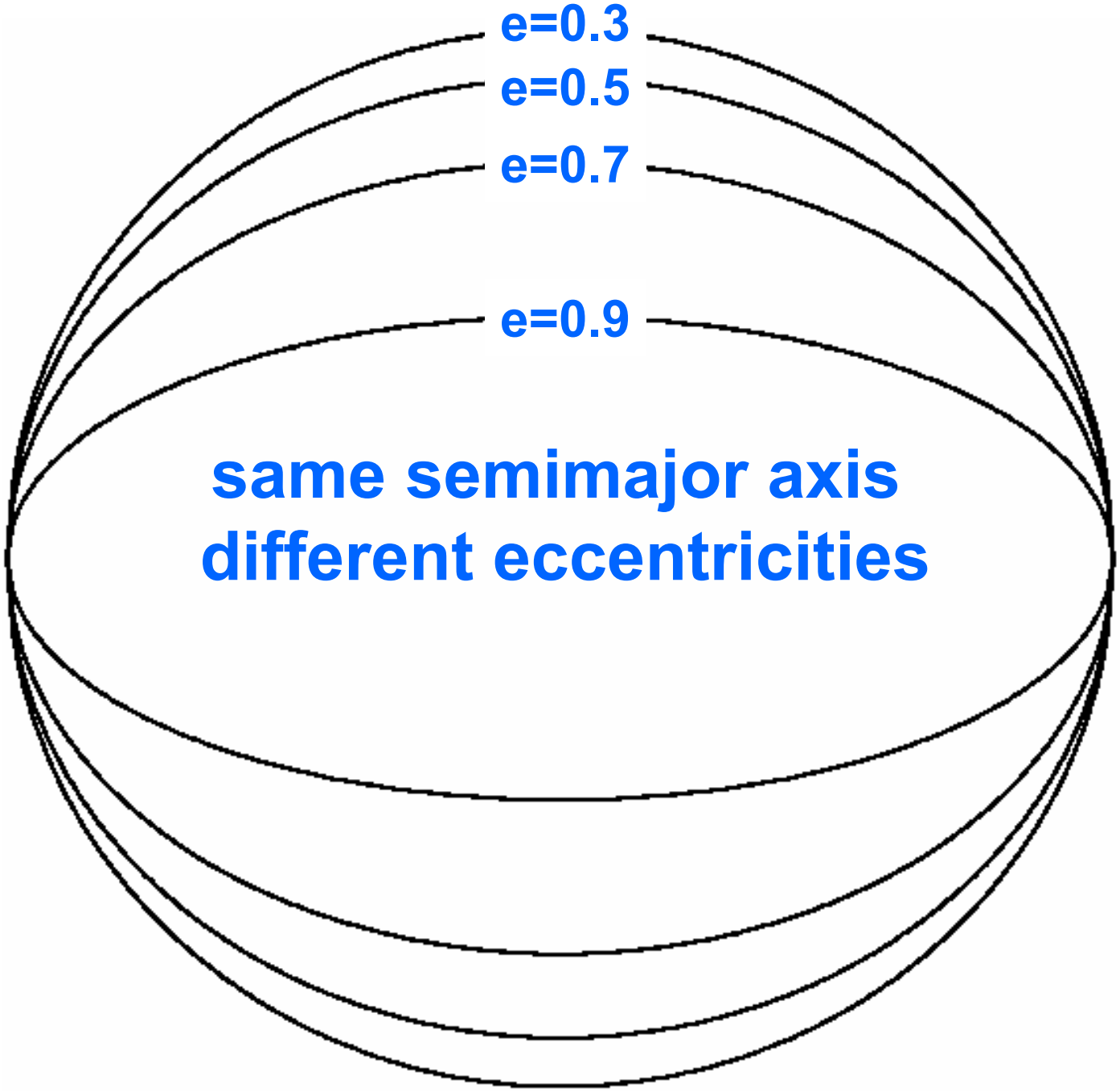
Salviati: Alexia Koelling
Sagredo: Lija Bentley-Phillips
Simplicio: Heath Blackerby

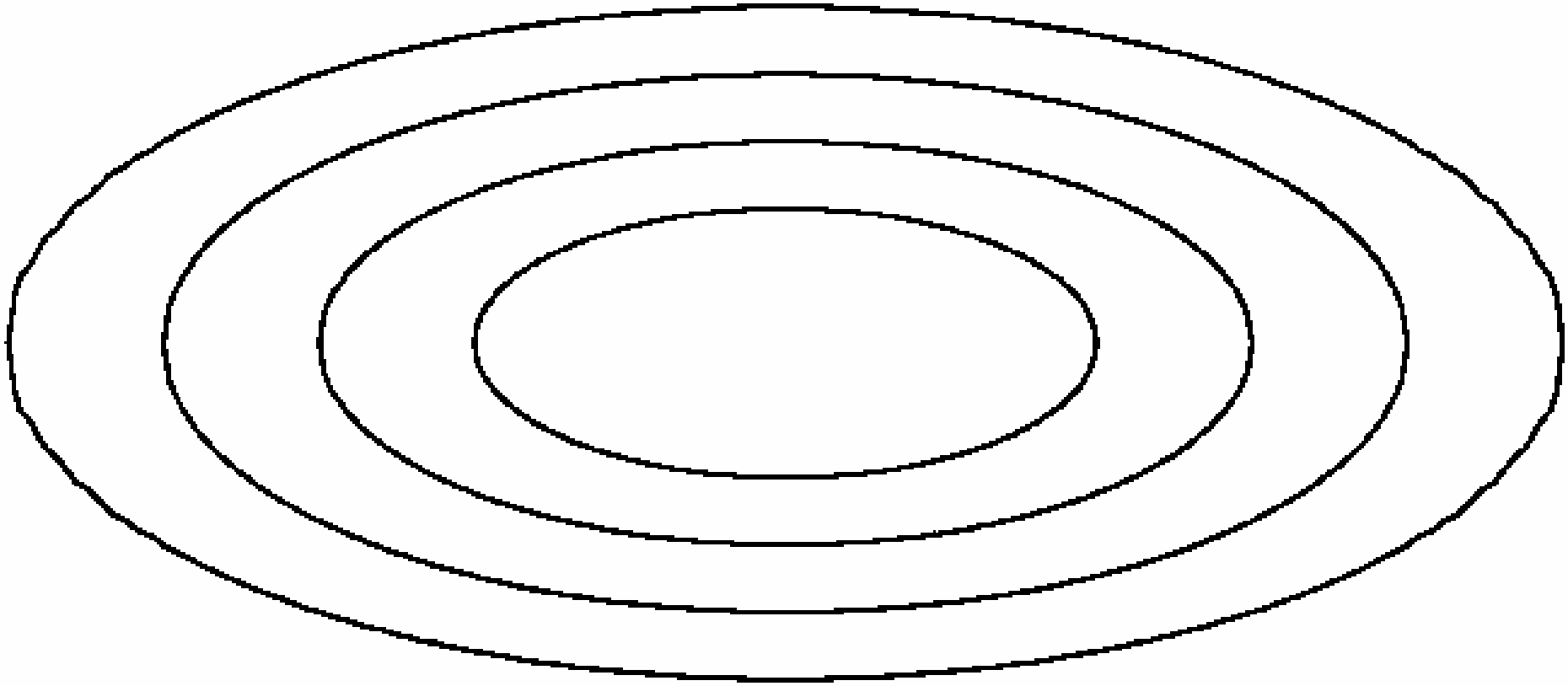
Kepler's 1st Law

circle




ellipse
focus

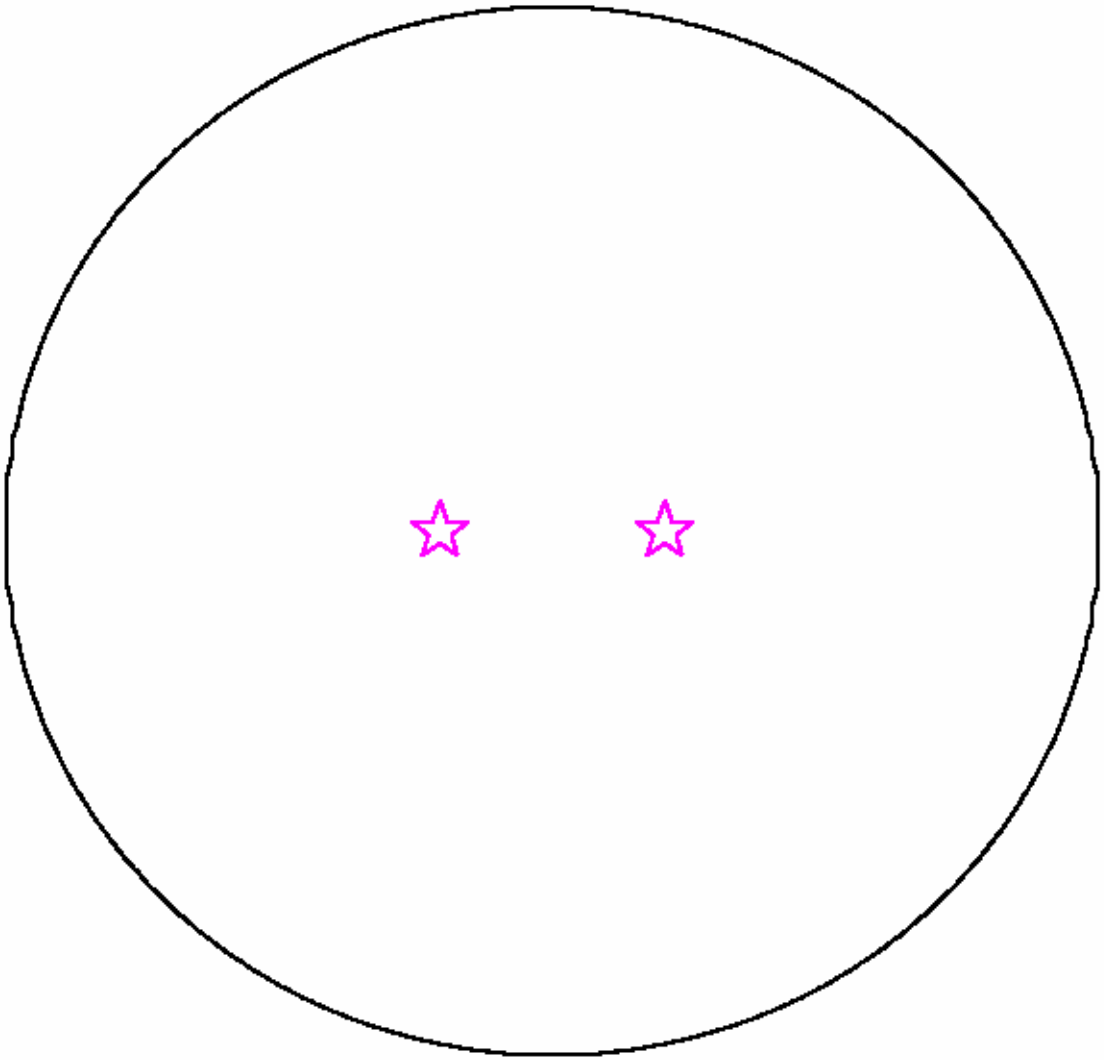

e=0.3
e=0.5
e=0.7
e=0.9
same semimajor axis
different eccentricities



same eccentricity

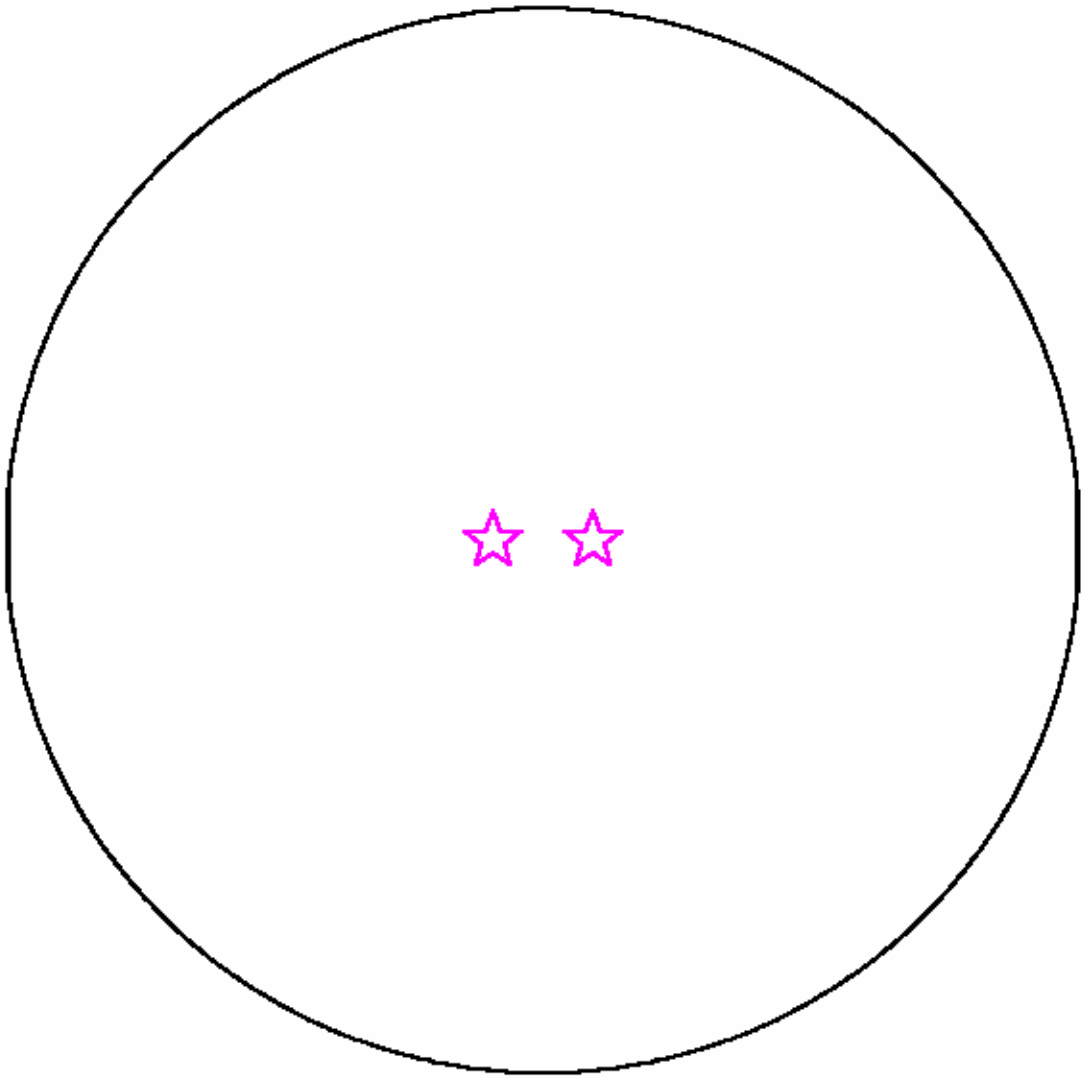
different semimajor axis

Mercury

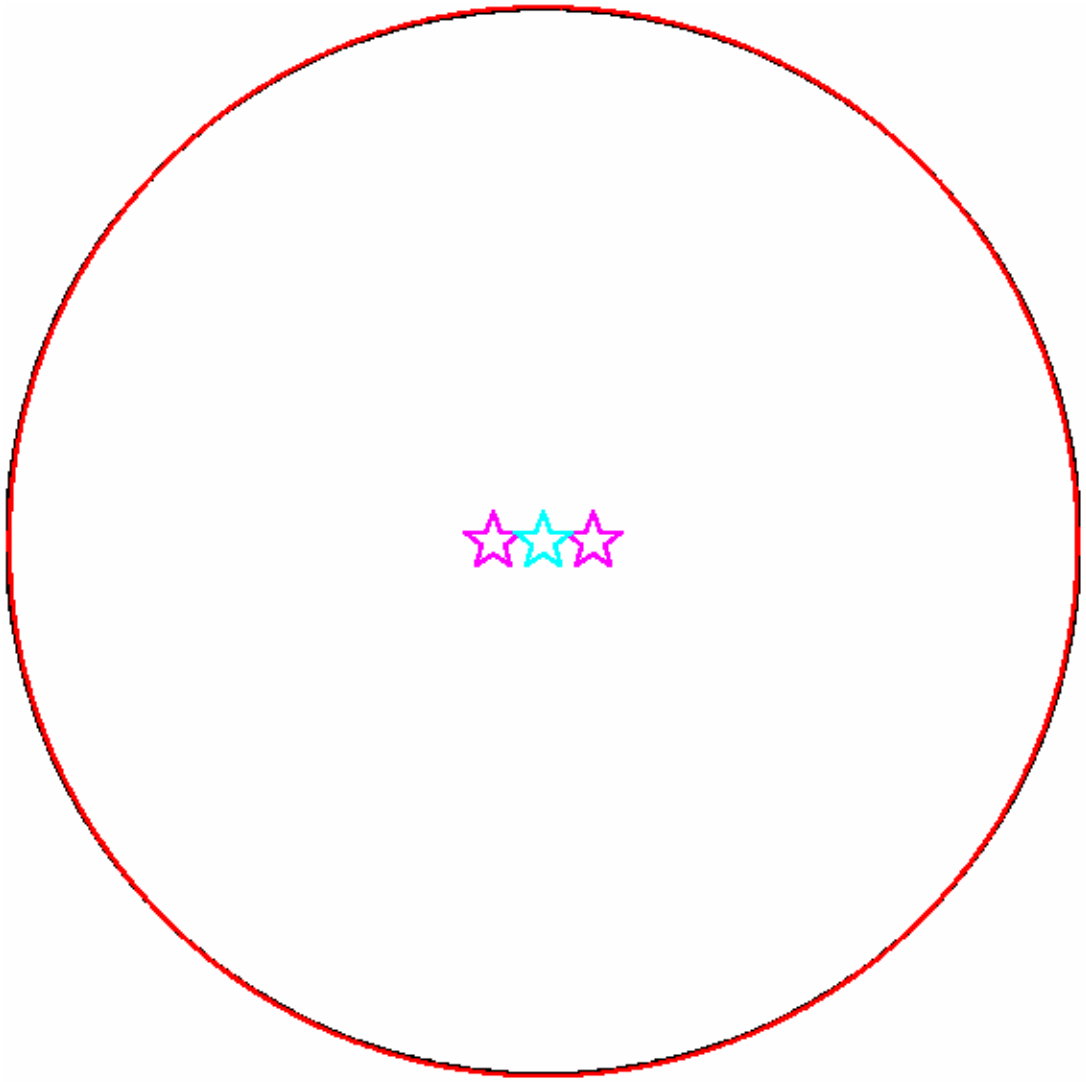


eccentricity = 0.2

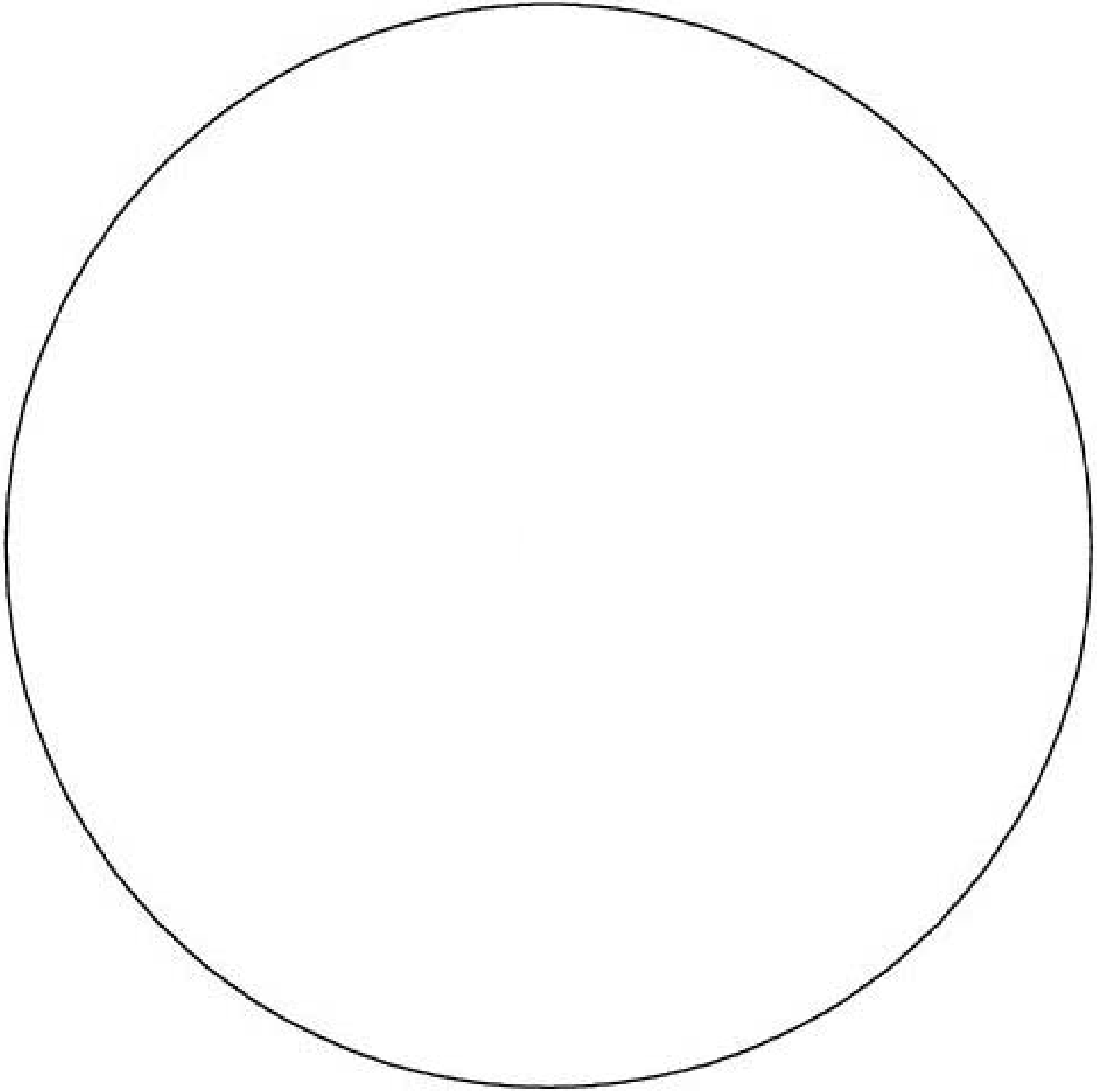
Mars

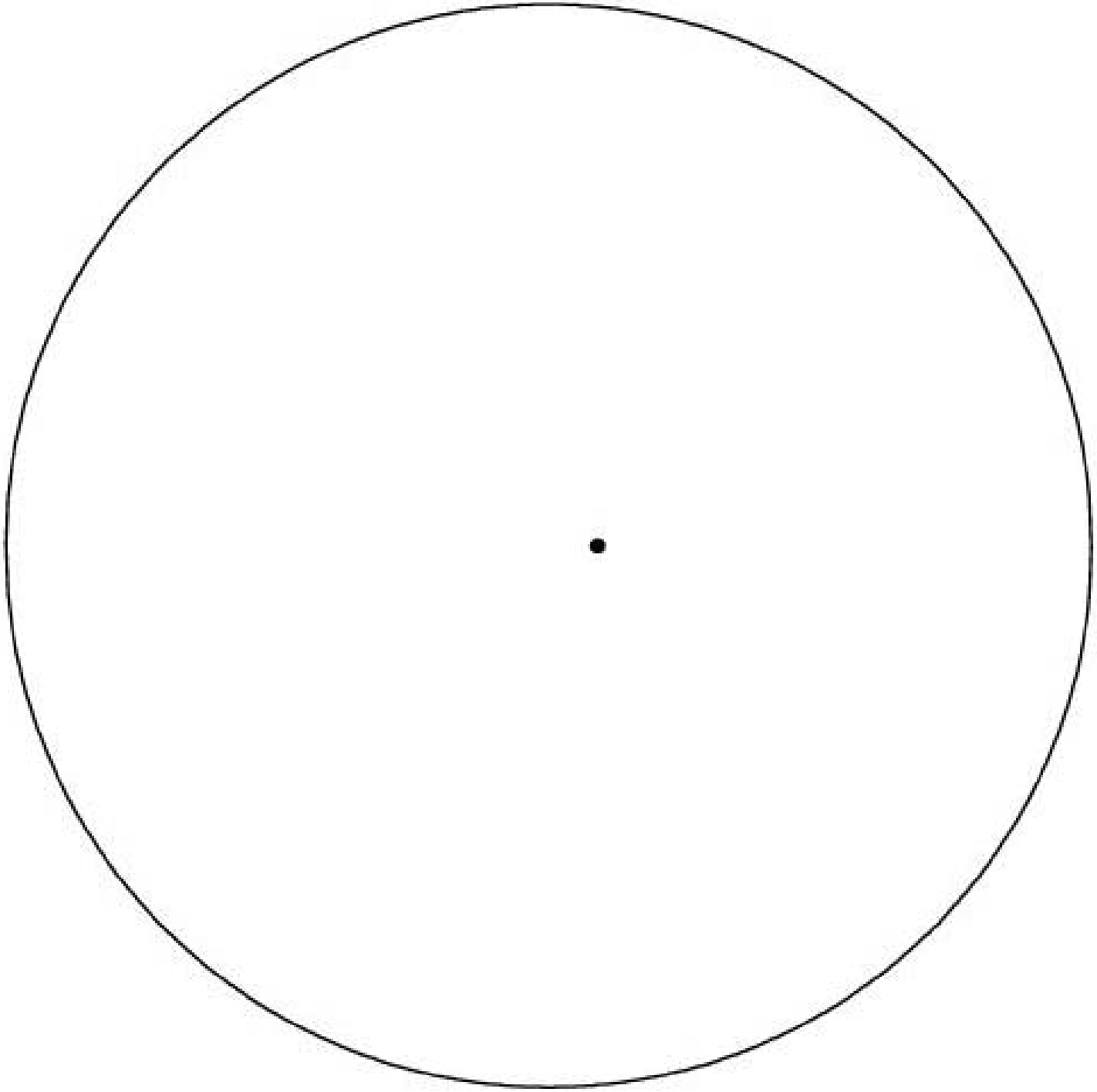


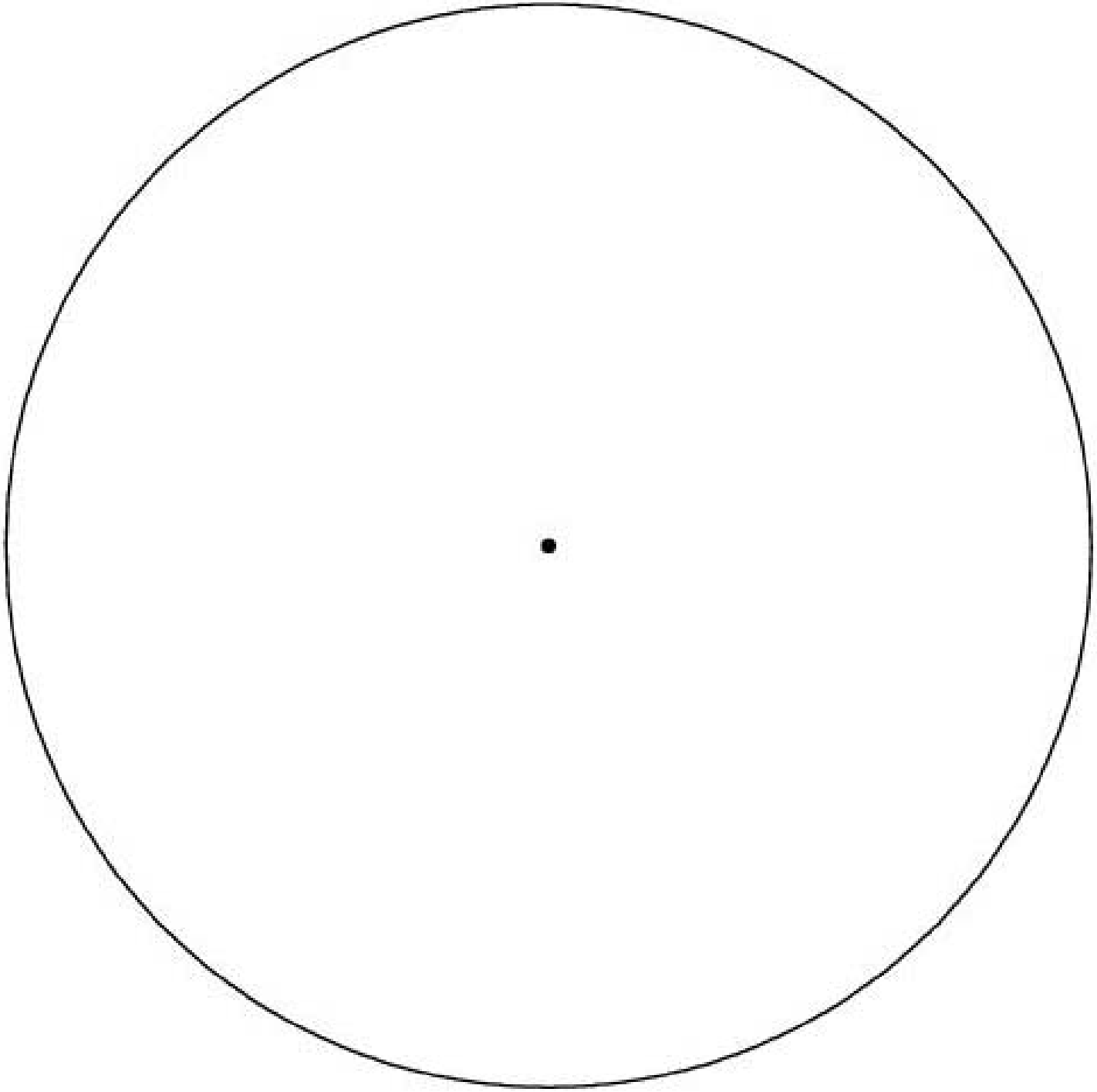
eccentricity = 0.09



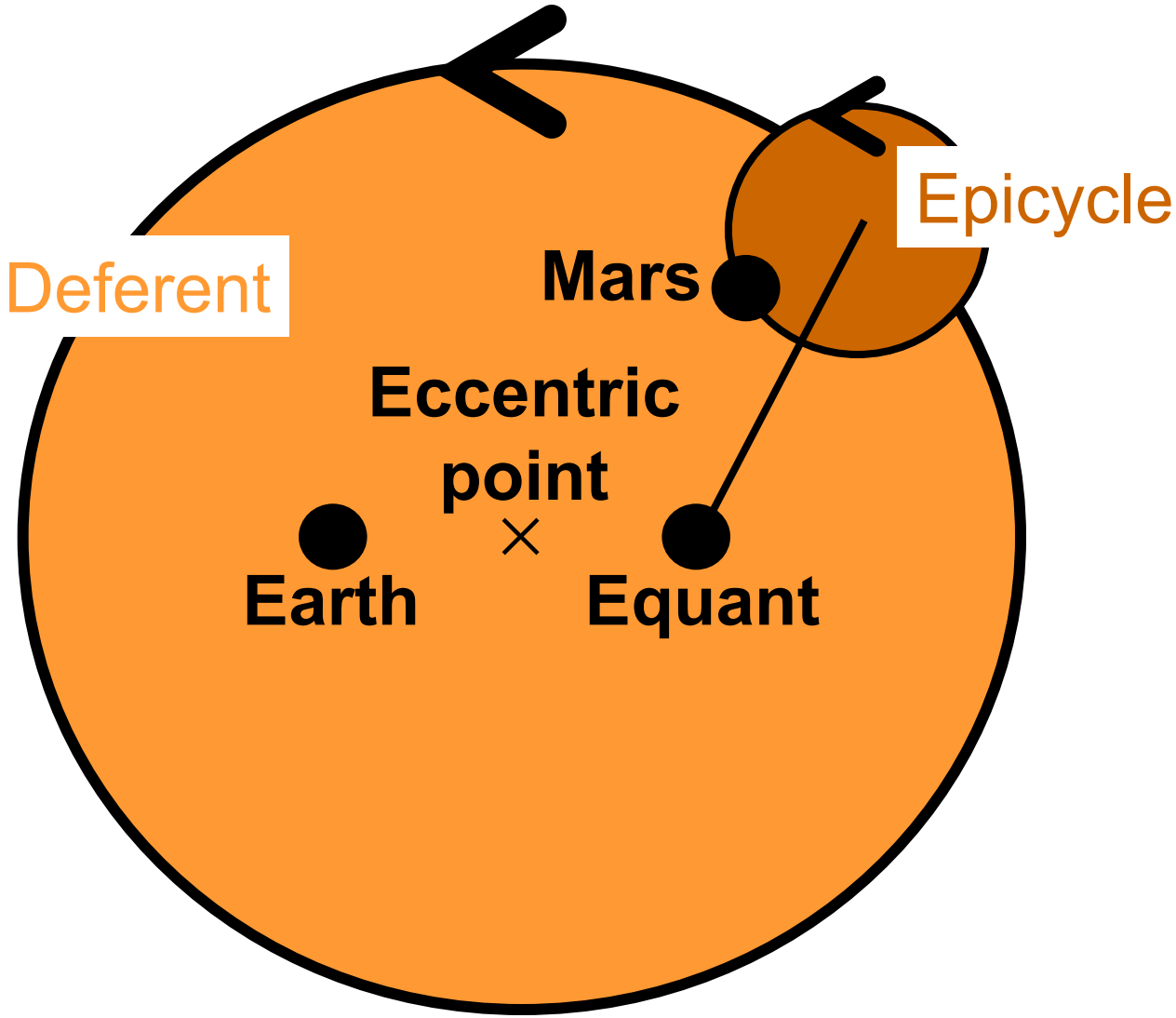
ellipse with eccentricity of Mars circle with same area



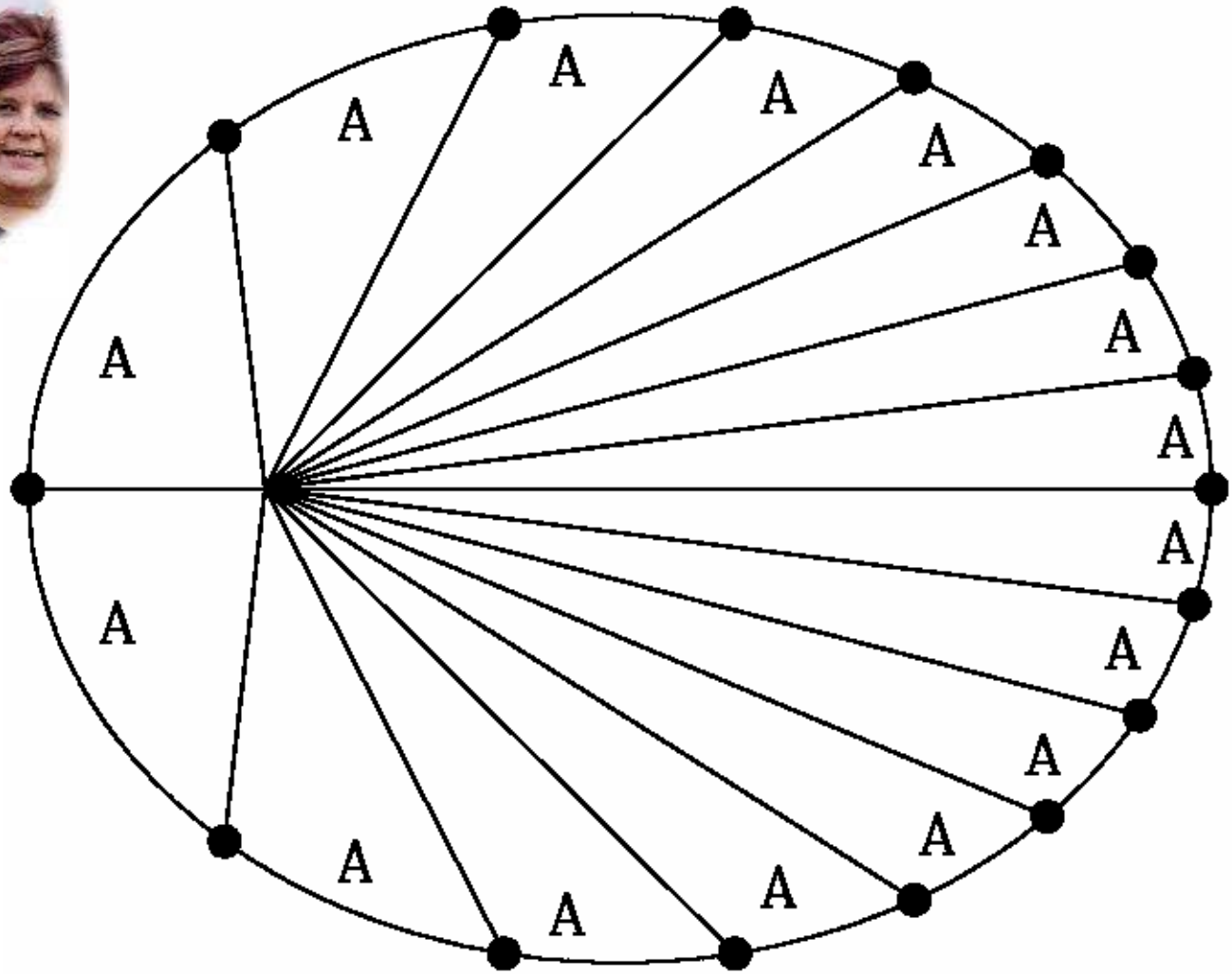


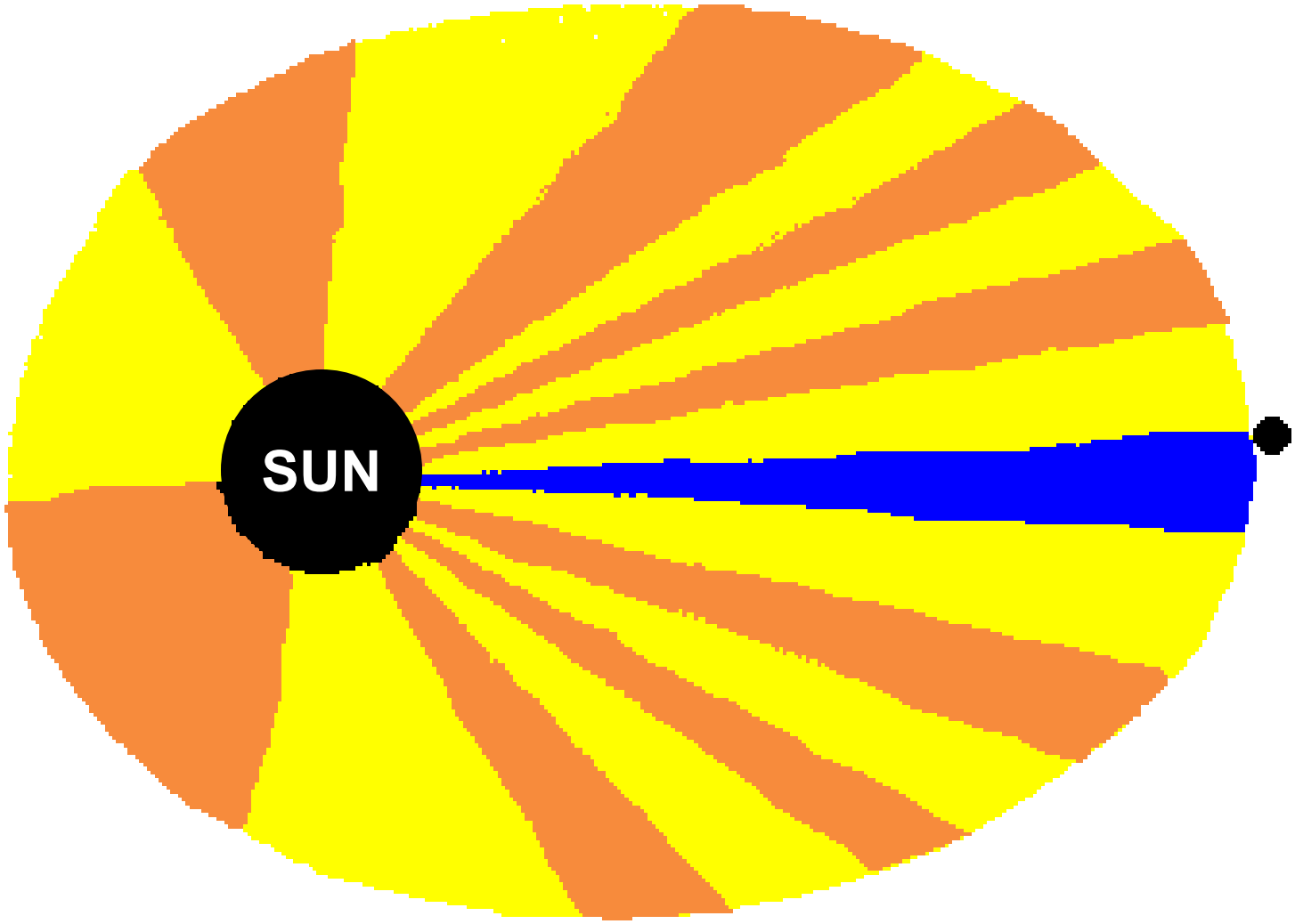


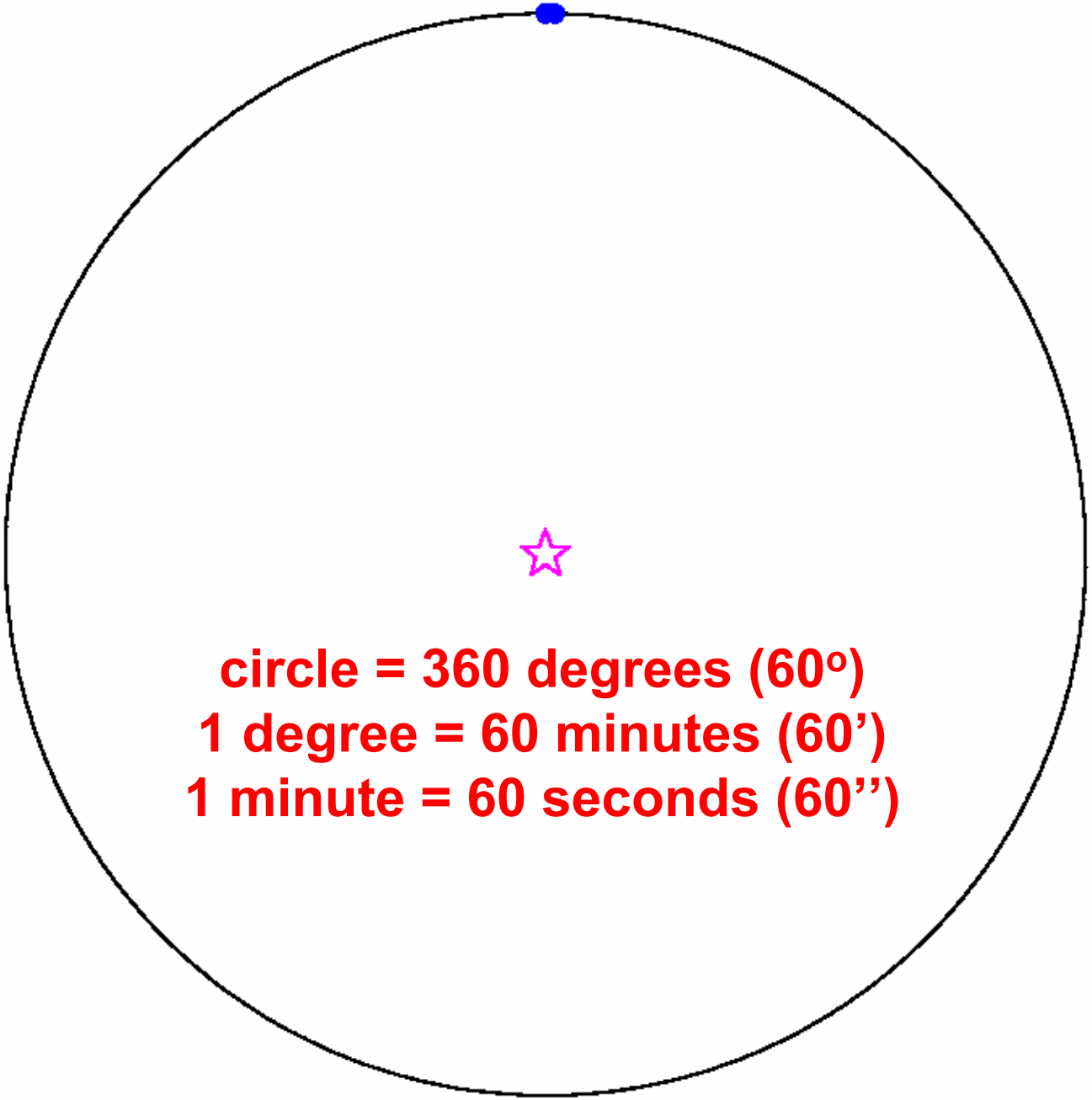
The Ptolemaic Epicycle

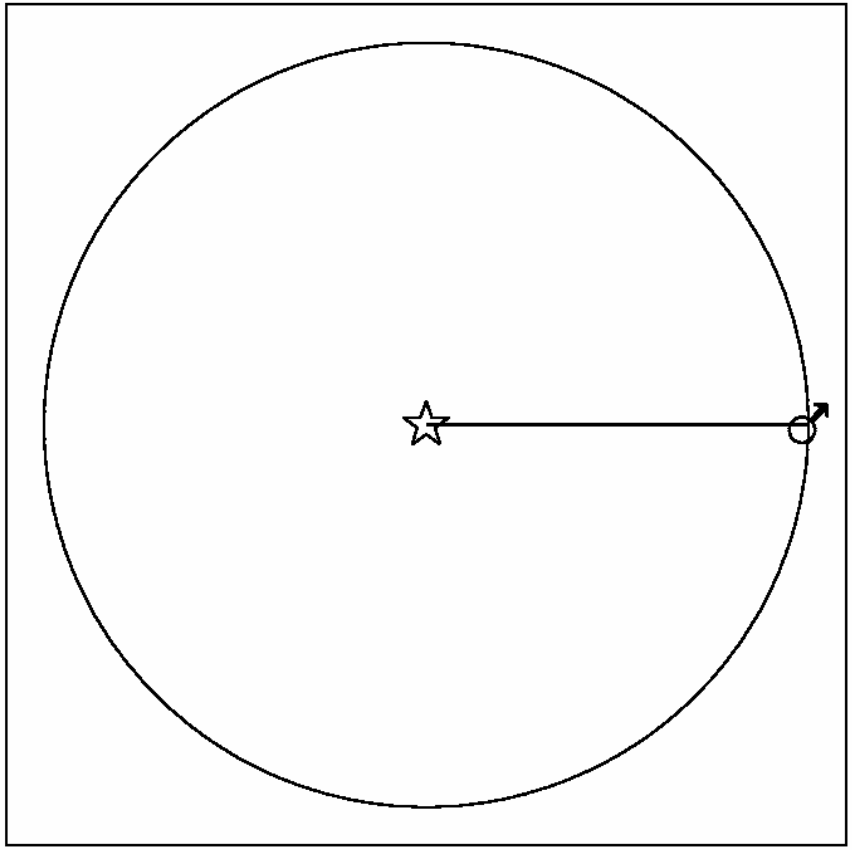


Kepler's 2nd Law

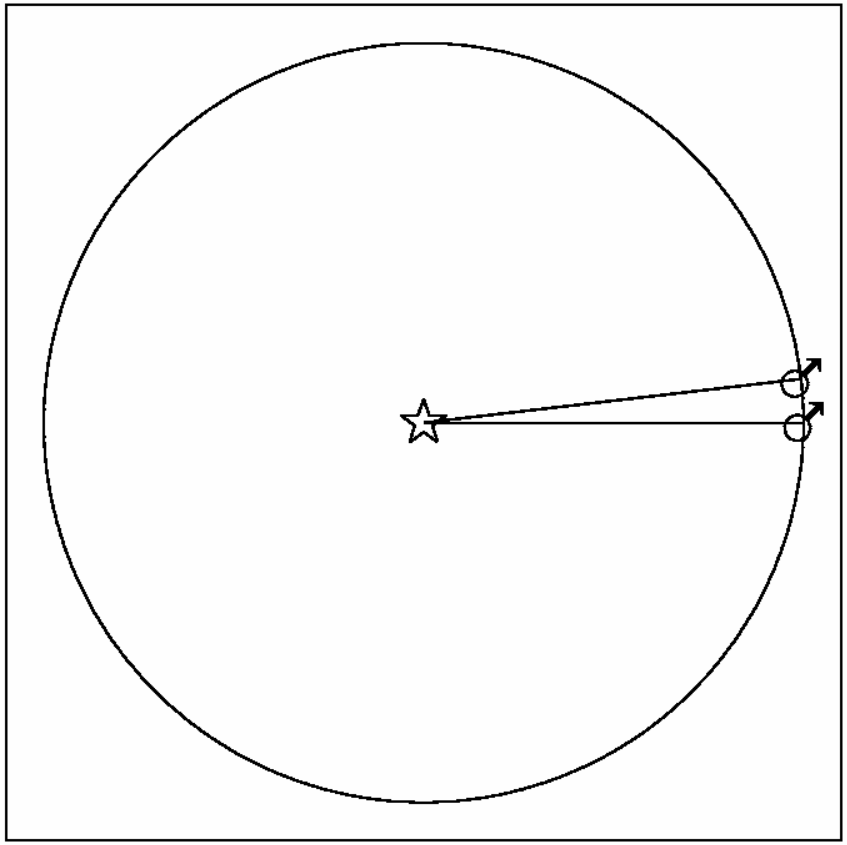



SUN


circle = 360 degrees (60°)
1 degree = 60 minutes (60’)
1 minute = 60 seconds (60’’)

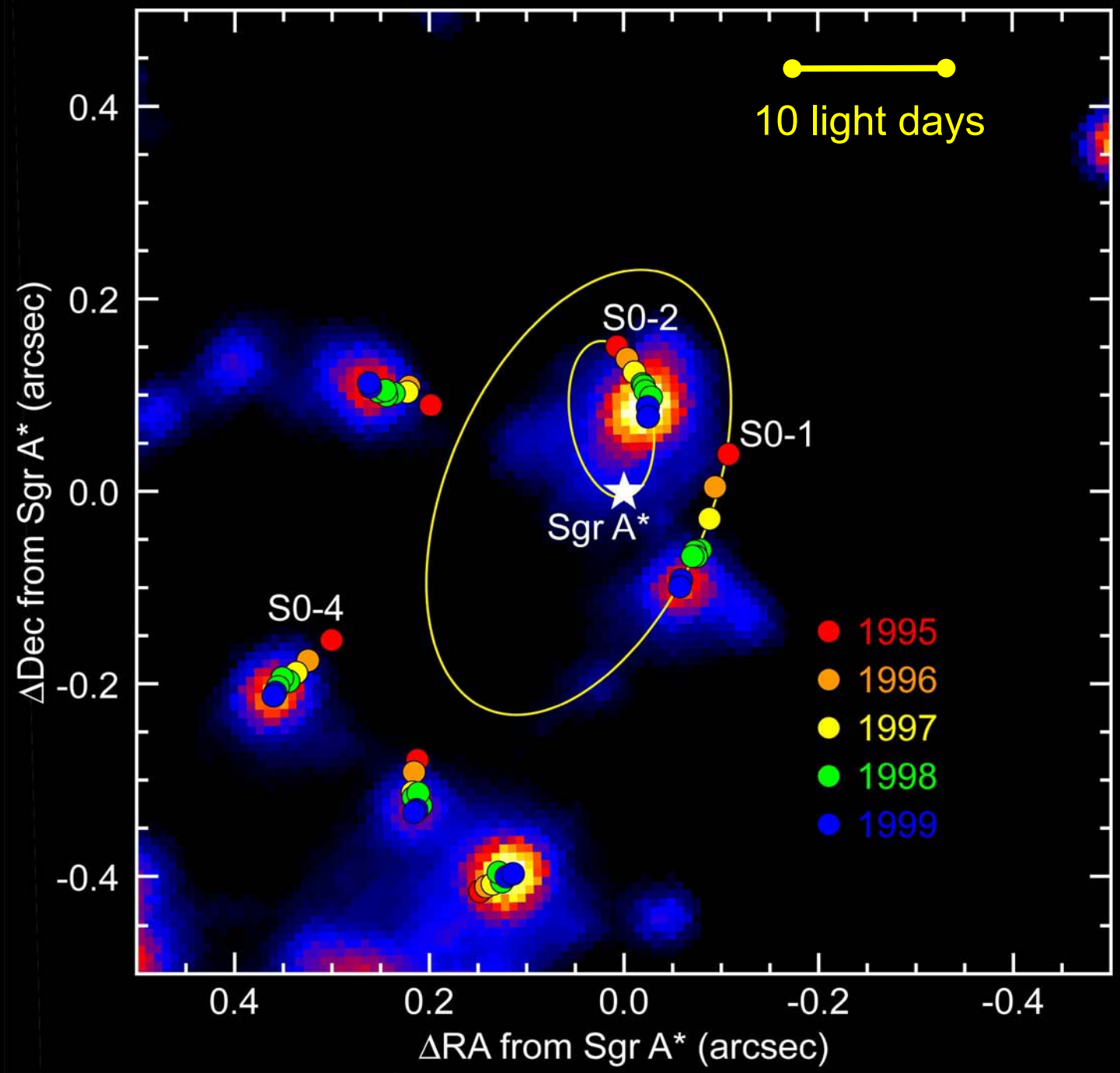


8 minutes of arc



50 X 8 minutes of arc

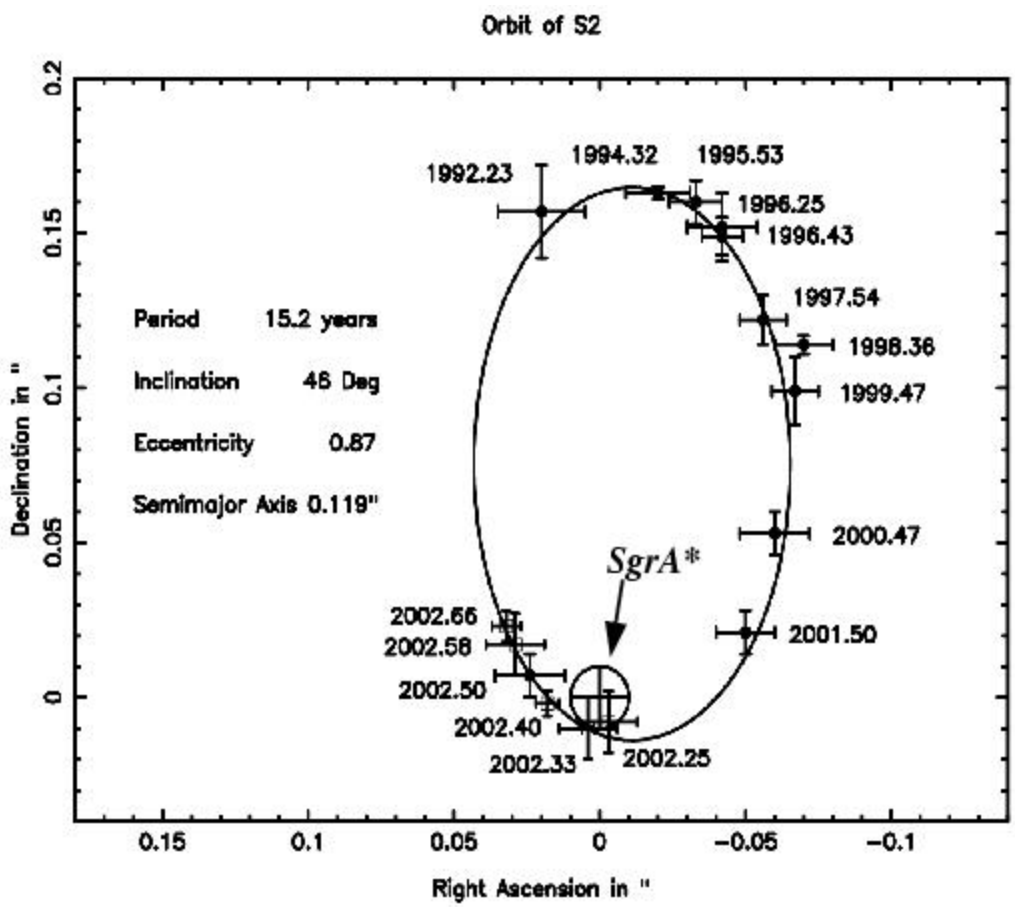
Ghez et al.


10 light days
S0-2
S0-1
Sgr A*
S0-4
1995
1996
1997
1998
1999
0.4
0.2
0.0
-0.2
-0.4
ΔDec from Sgr A* (arcsec)
ΔRA from Sgr A* (arcsec)

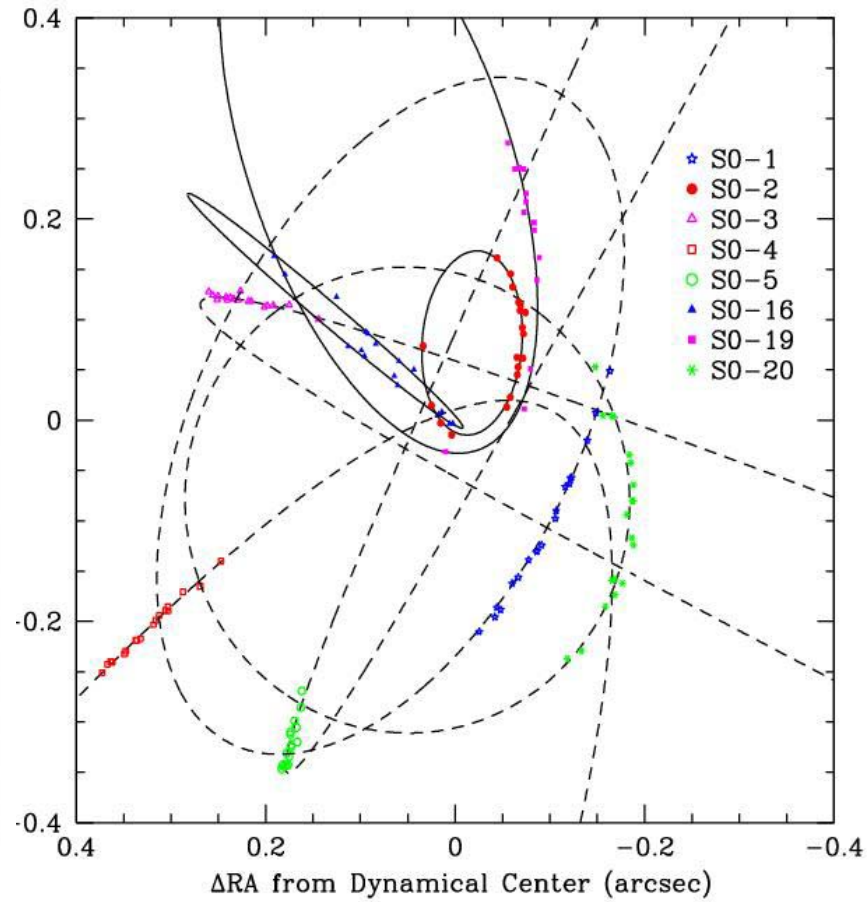
Orbits near the galactic center

$S2: \quad 15M_{\odot}; 7R_{\odot}$

Pericenter passage: $100\text{AU}=2000R_S; 11\times10^6$ mph

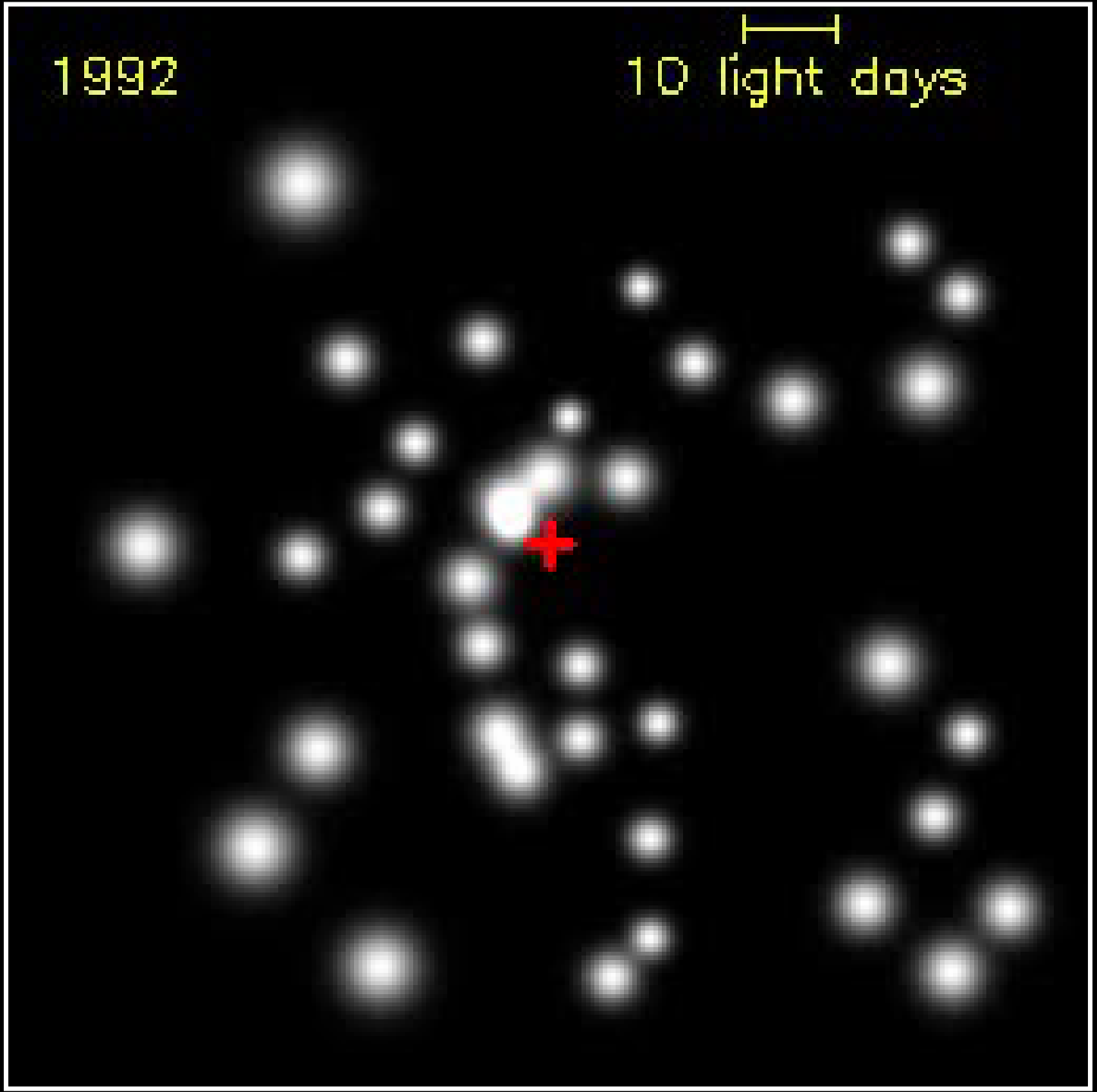


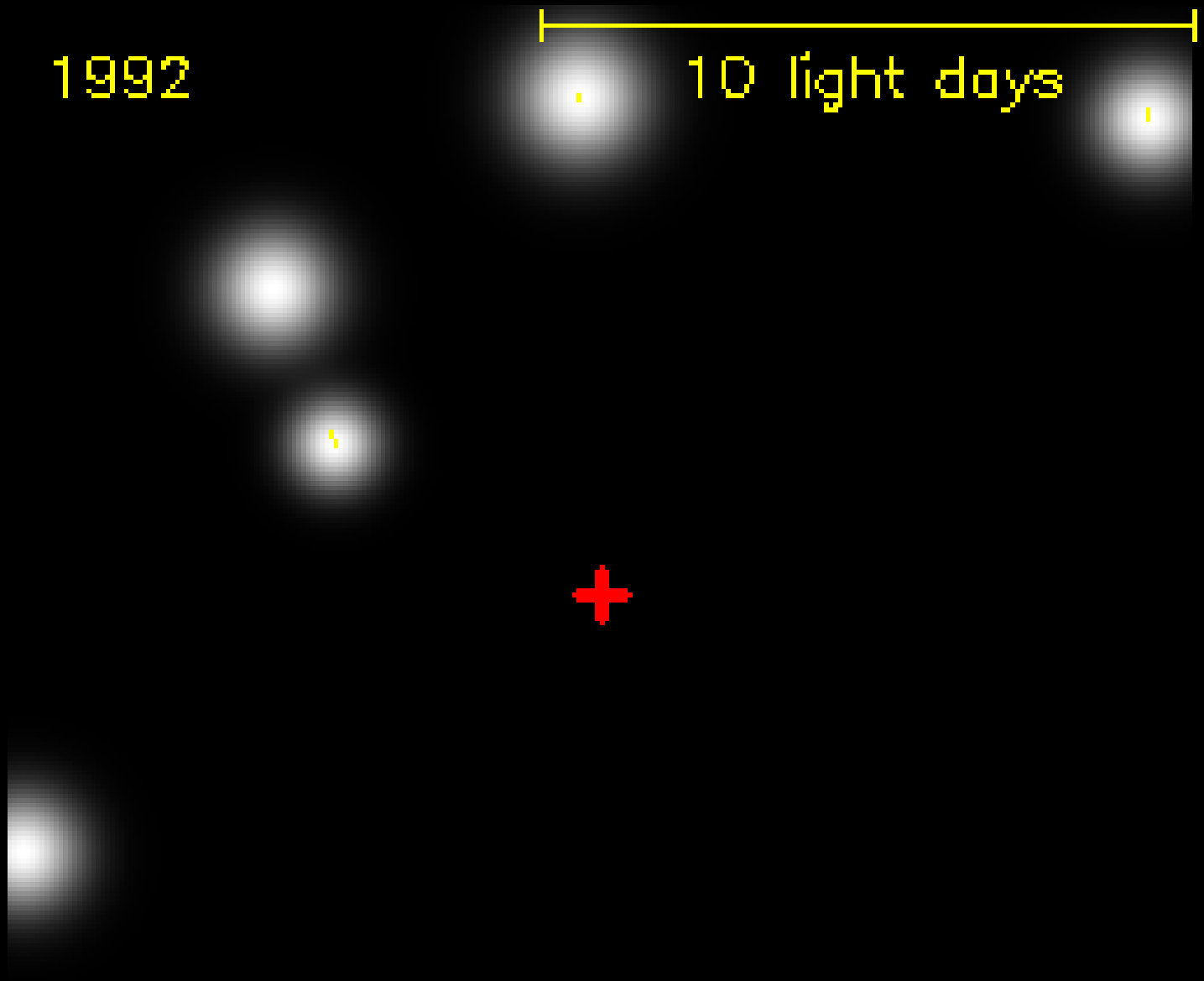
Schodel et al. (2002)



Ghez et al. (2003)

Schodel et al. 2002



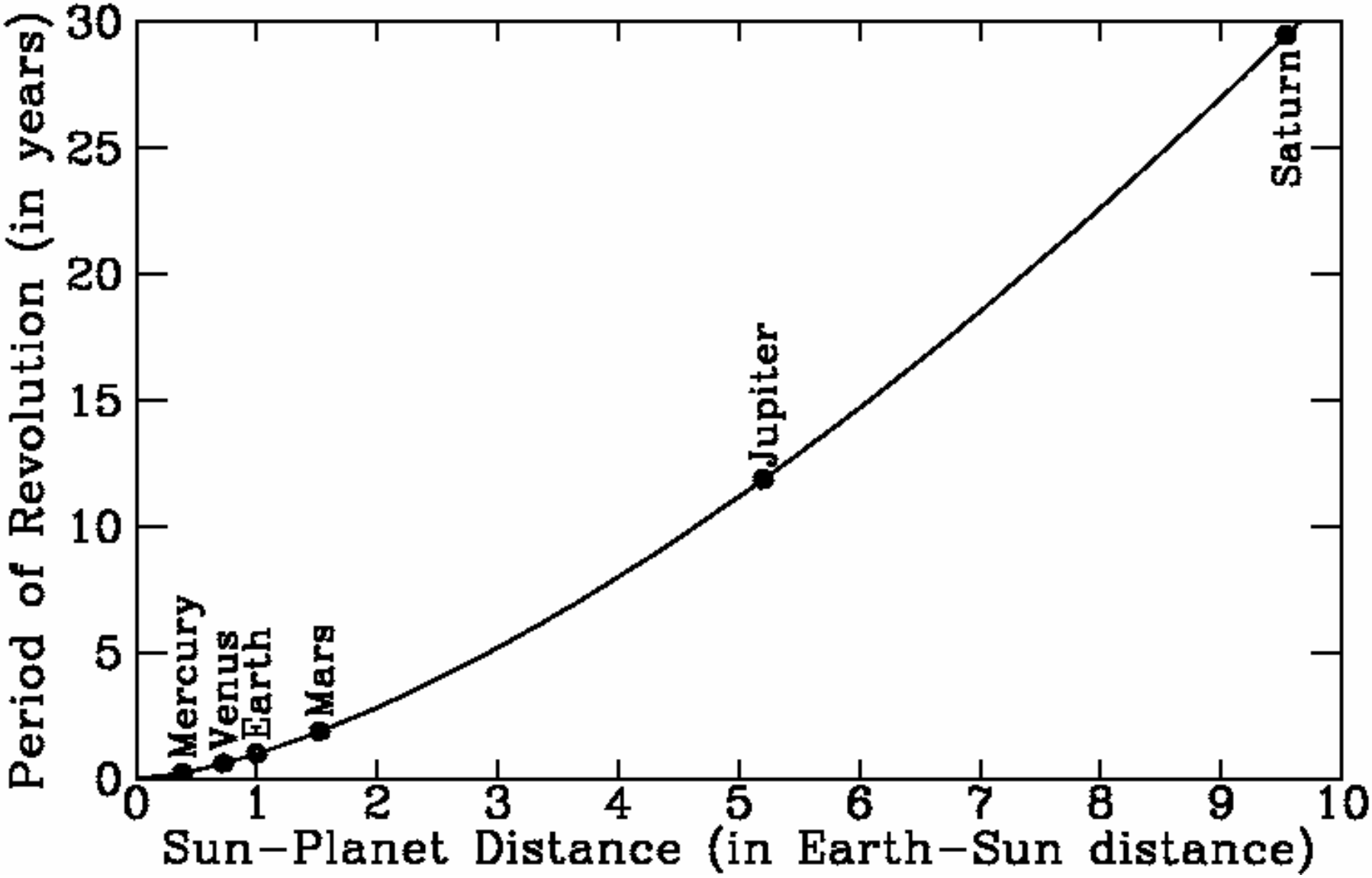


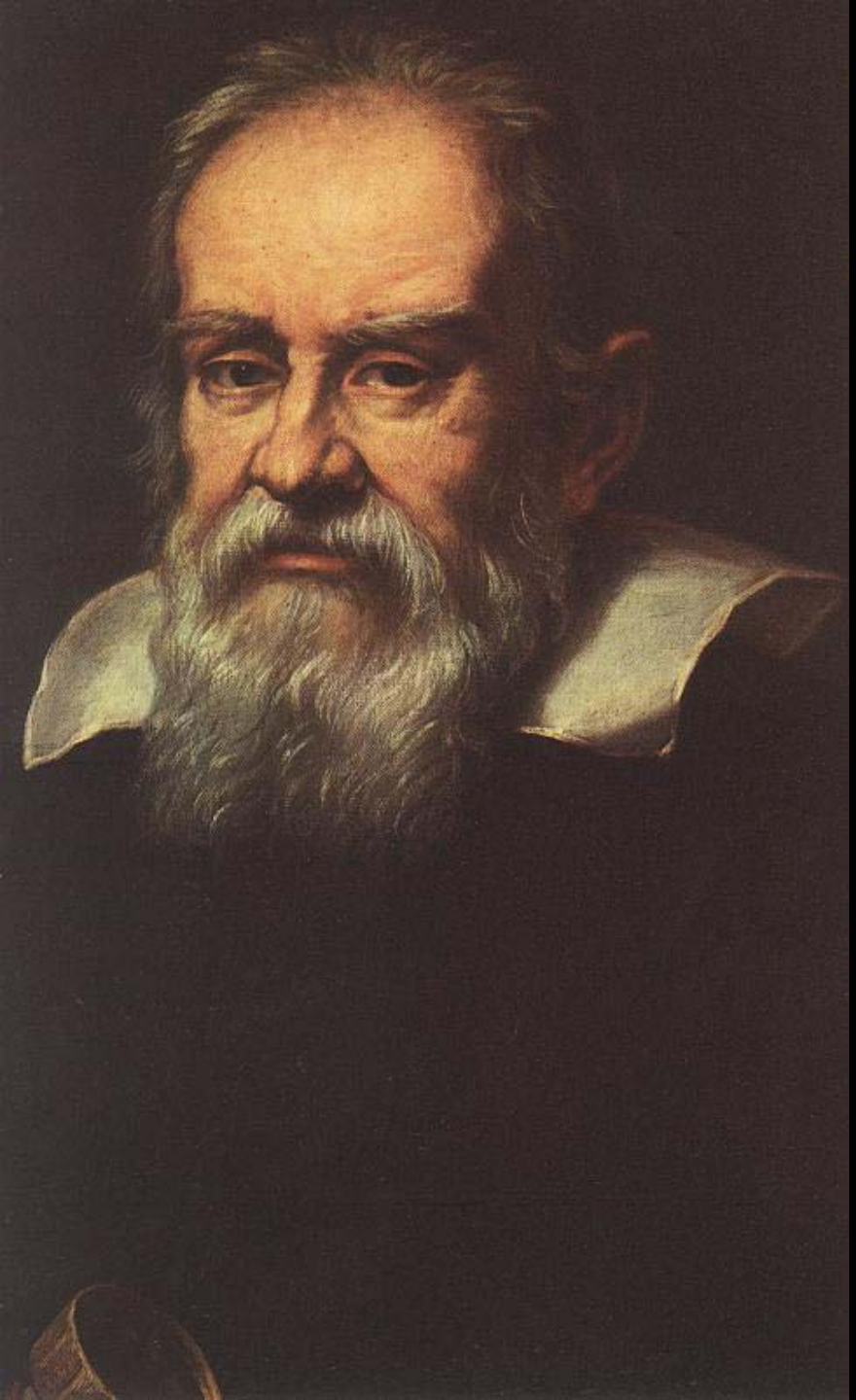
Schodel et al. 2002

Kepler's Third Law: period squared = semimajor axis cubed

Planet	period P years	semimajor axis a astronomical units	P^2	a^3
Mercury	0.24	0.06	0.06	0.06
Venus	0.62	0.72	0.4	0.4
Earth	1.0	1.0	1.0	1.0
Mars	1.88	1.52	1.5	1.5
Jupiter	11.9	5.2	140	140
Saturn	29.5	9.5	870	870
Moon	1/12	1/144	1/240	1/14million

Kepler's Third Law: period squared = semimajor axis cubed





Galileo Galilei
1564 – 1642

by
Justus Sustermans
Palazzo Pitti
Firenze

Judith Beheading Holofernes
Caravaggio 1598
Galleria Nazionale d'Arte Antica, Rome

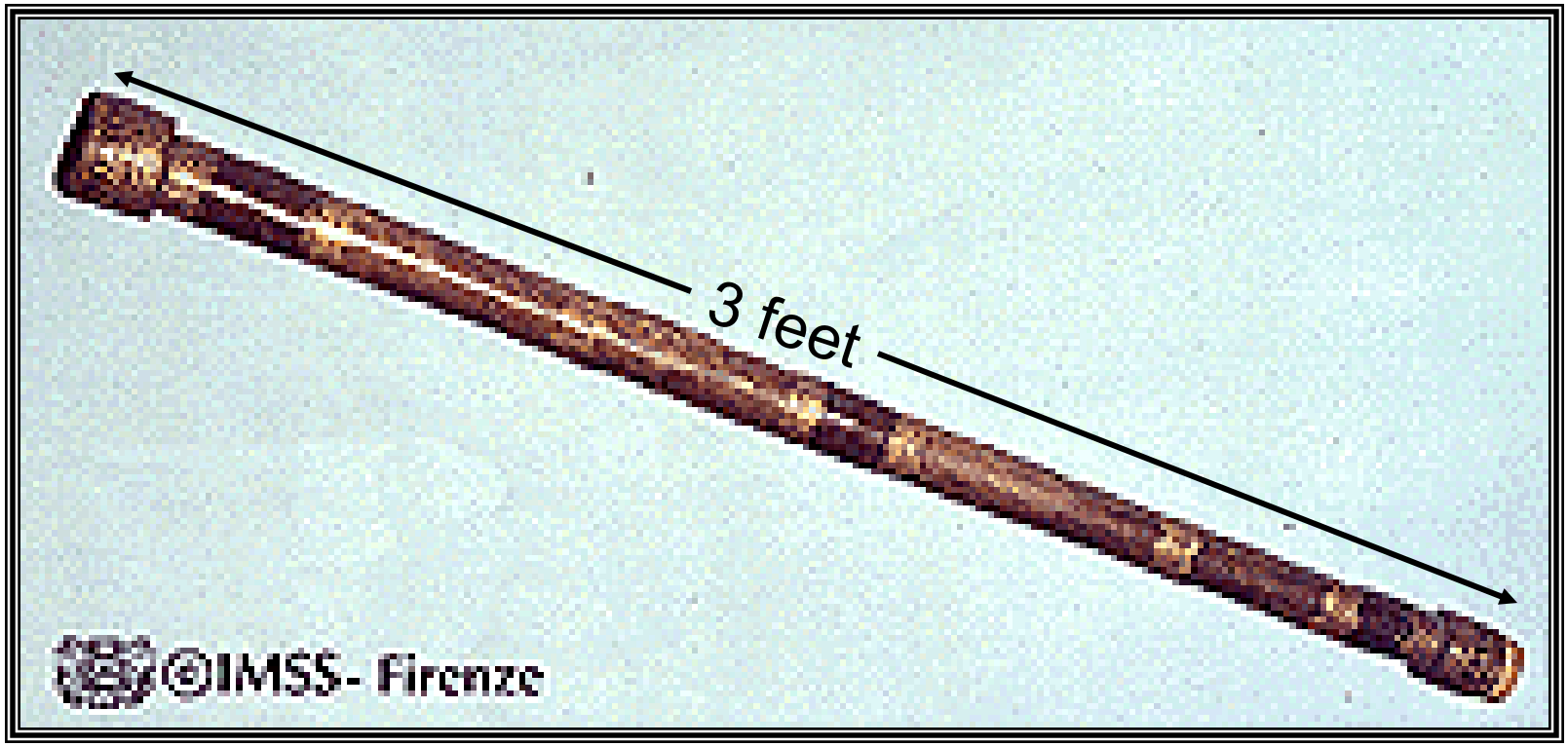
Ecce Homo
Caravaggio
1606
Palazzo Rosso,
Genoa

Maffeo Barberini
(1568 - 1644)

Urban VIII
(1623 - 1644)

Caravaggio 1599
Private Collection, Firenze

Caravaggio
The Sacrifice of Isaac
1601-02
Galleria degli Uffizi, Florence



Museo di Storia della Scienza, Firenze

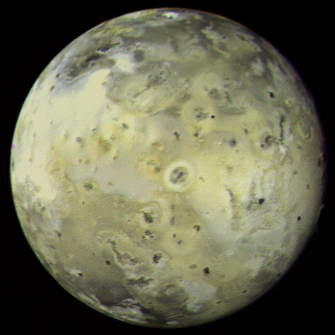
Wooden tube covered with red leather decorated in gold
21 X magnification
16mm objective lens

Museo di Storia della Scienza

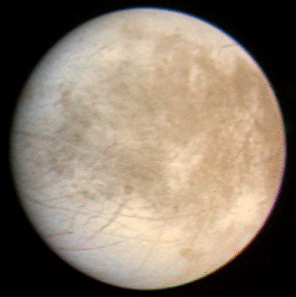
The Power of 3!

1. Spots on the Sun
2. Mountains on the moon
3. Phases of Venus
4. Rings of Saturn
5. Stars are distant
6. Stars invisible to the naked eye
7. Milky way made of stars
8. Moons of Jupiter

Four of Jupiter's 61 moons

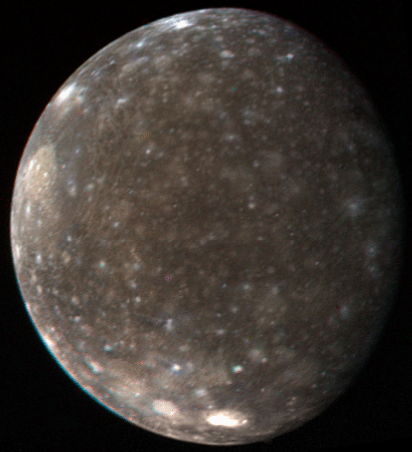


Io



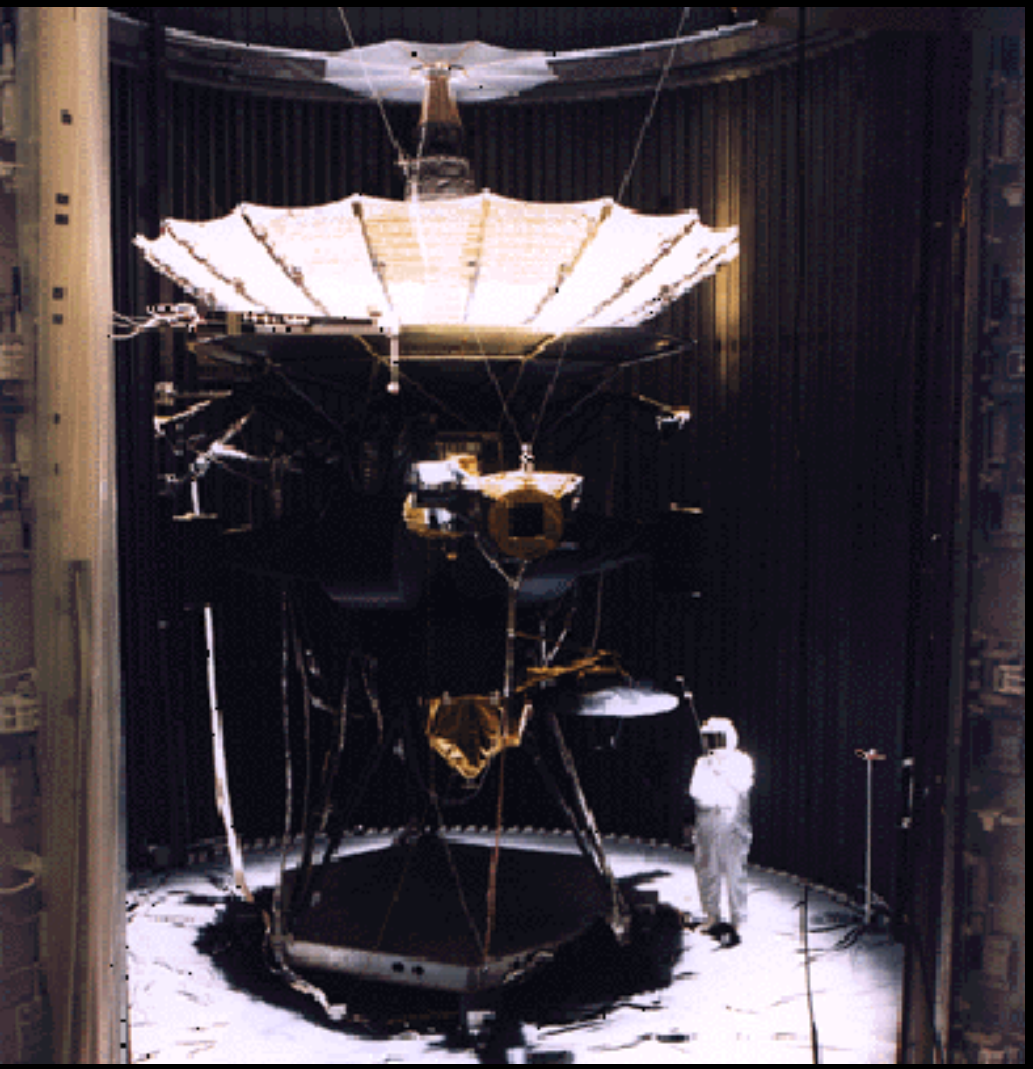
Europa

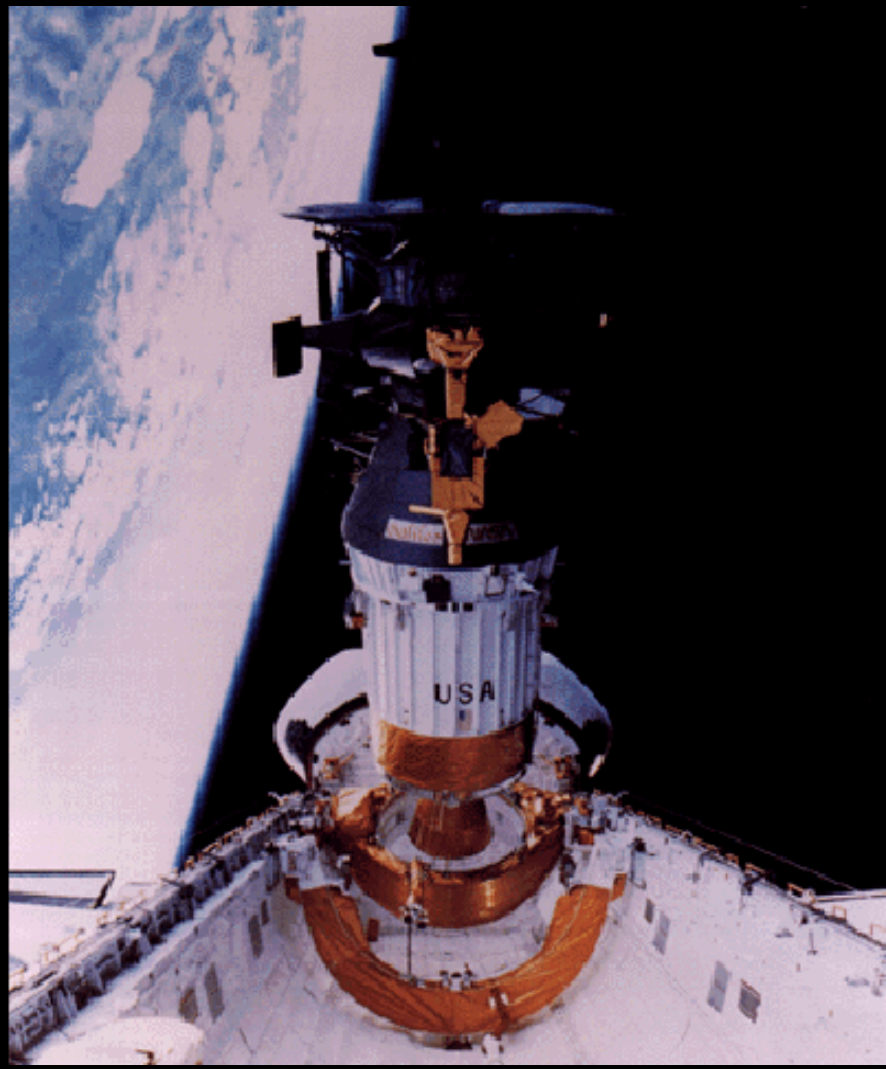
Ganymede



Callisto

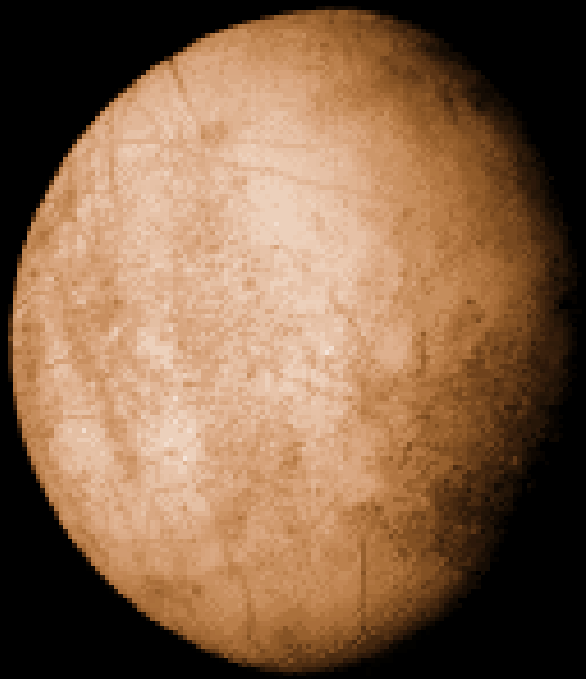
Galileo

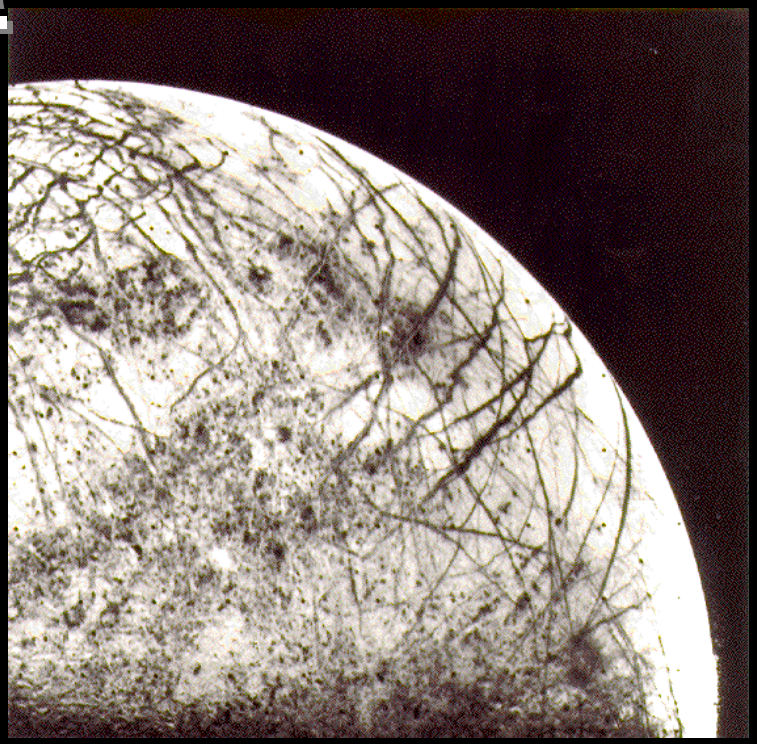


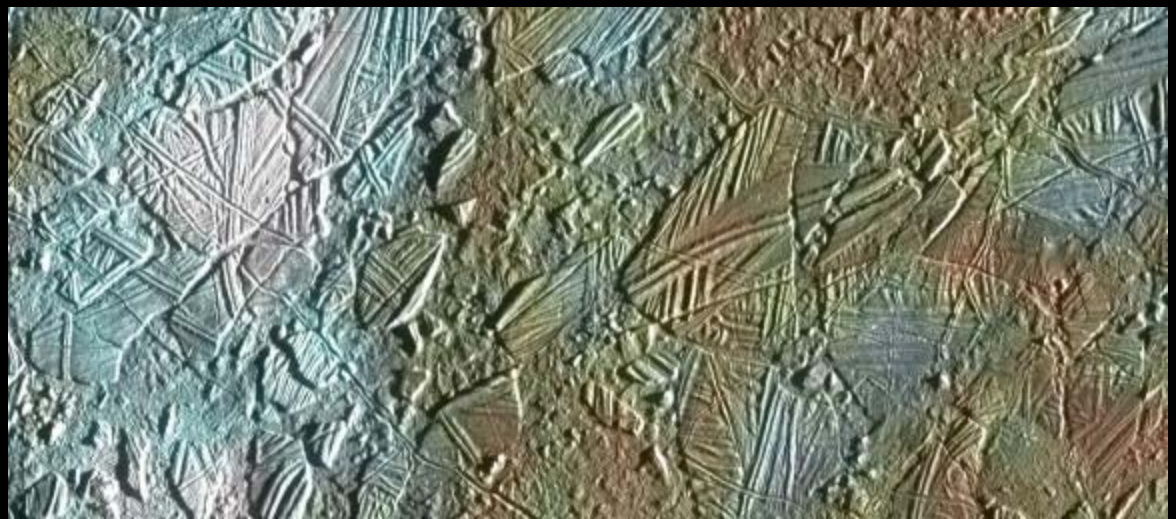


launched 1989 arrived at Jupiter 1995 plunged into Jupiter 2003

Europa

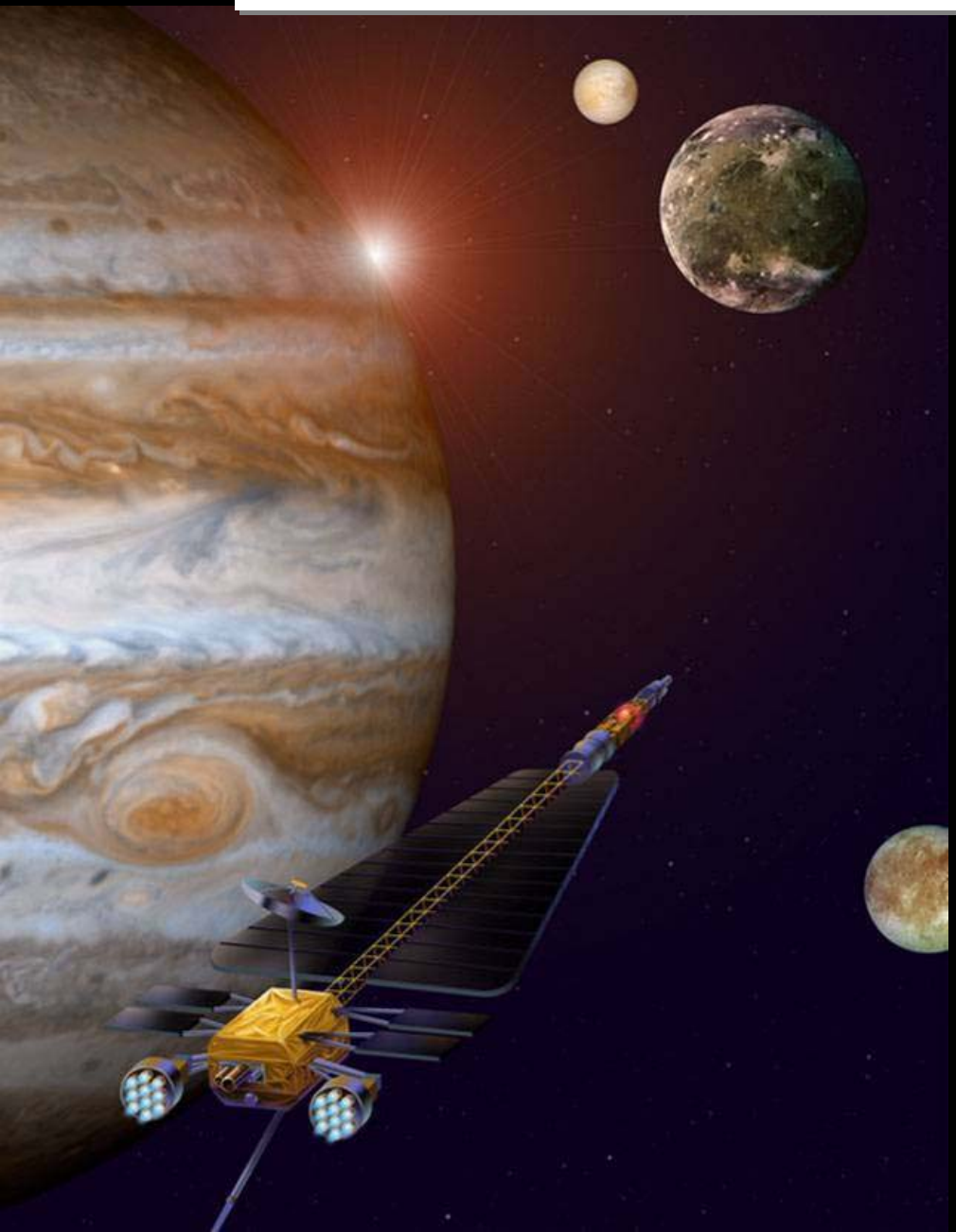


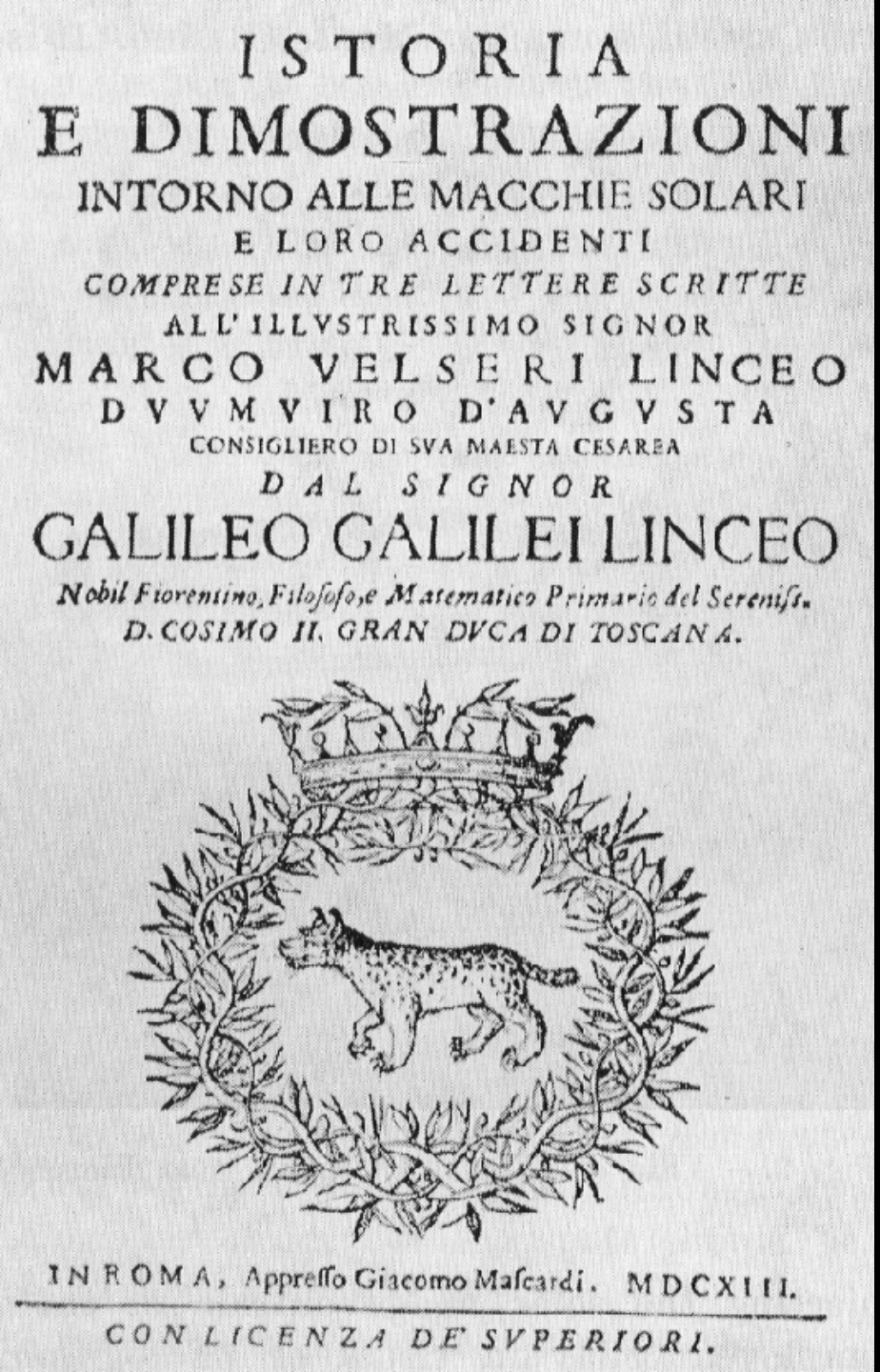




Giant tube worms at undersea hydrothermal vents

Jupiter Icy Moons Orbiter

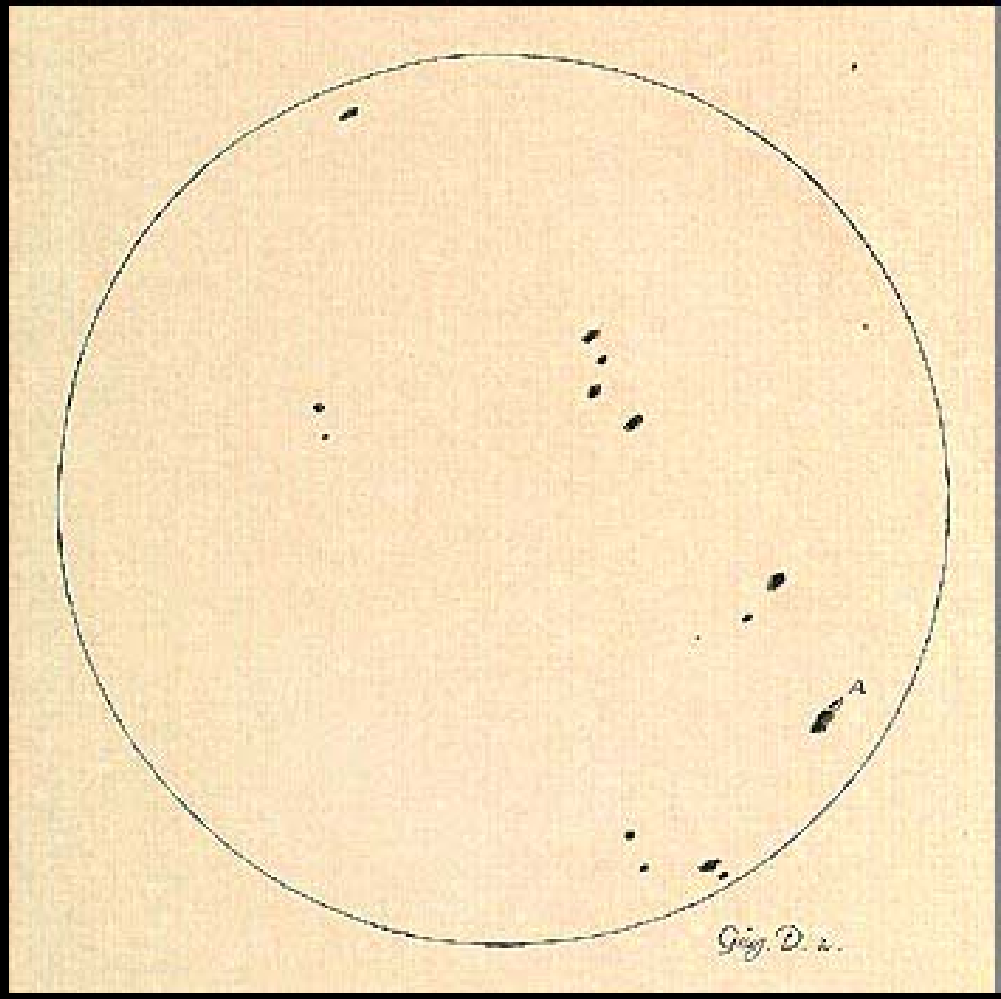




ISTORIA
E DIMOSTRAZIONI
INTORNO ALLE MACCHIE SOLARI
E LORO ACCIDENTI
COMPRESE IN TRE LETTERE SCRITTE
ALL'ILLVSTRISSIMO SIGNOR
MARCO VELSERI LINCEO
DVVMVIRO D'AVGVSTA
CONSIGLIERO DI SVA MAESTA CESAREA
DAL SIGNOR
GALILEO GALILEI LINCEO
Nobil Fiorentino, Filosofo, e Matematico Primario del Serenis.
D. COSIMO II. GRAN DVCA DI TOSCANA.

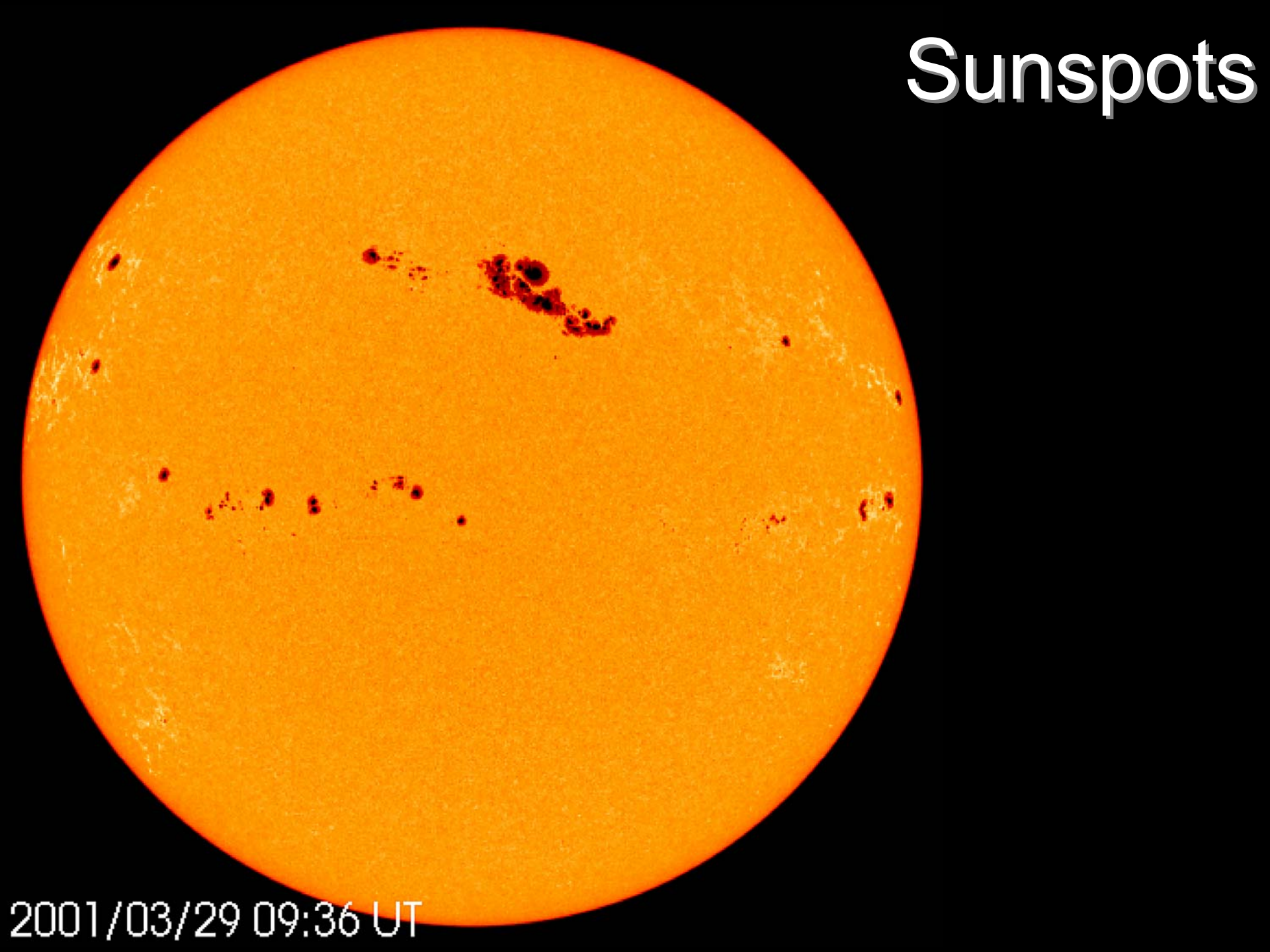
IN ROMA, Appresso Giacomo Mascardi. MDCXIII.

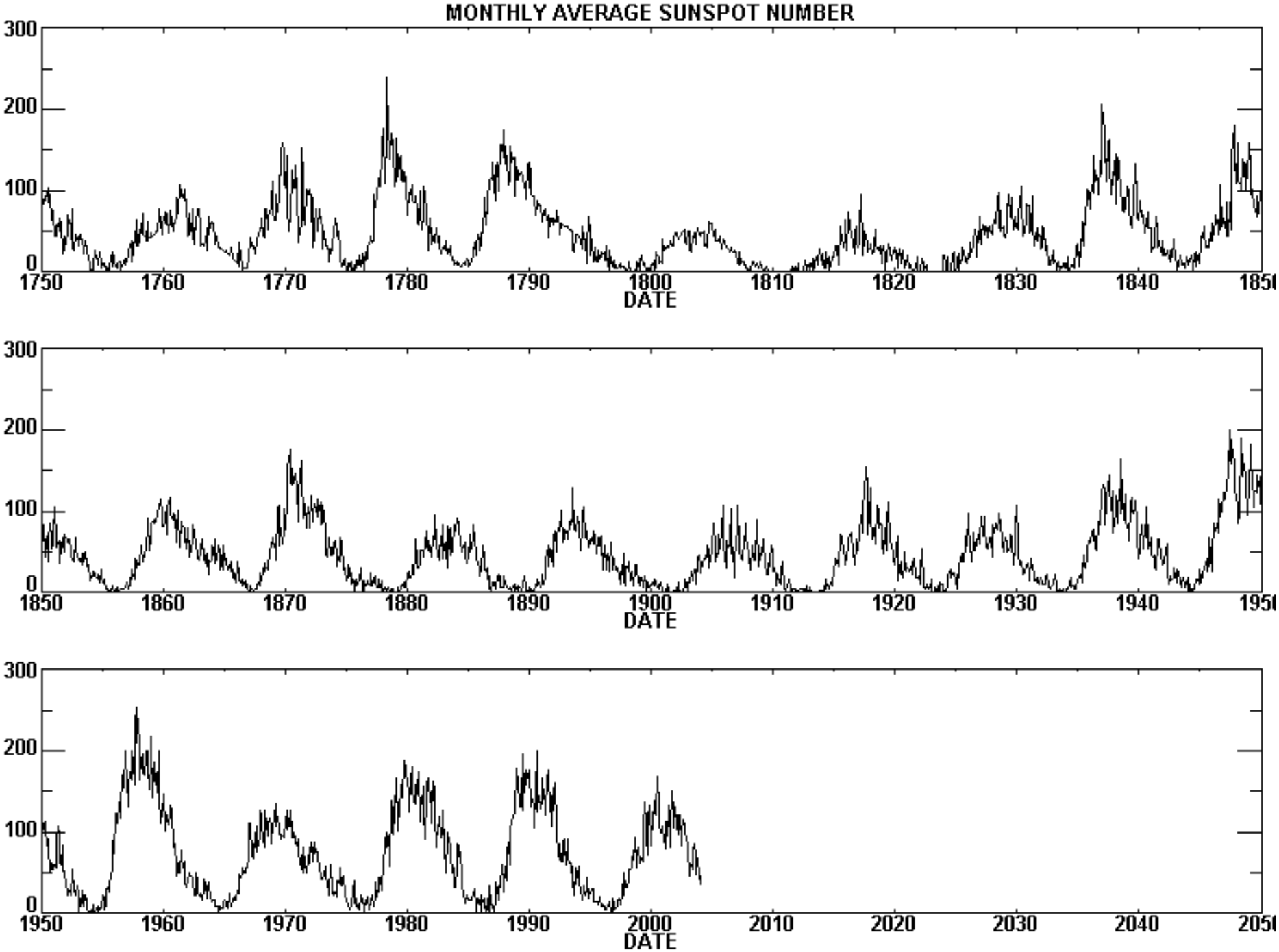
CON LICENZA DE' SVPERIORI.

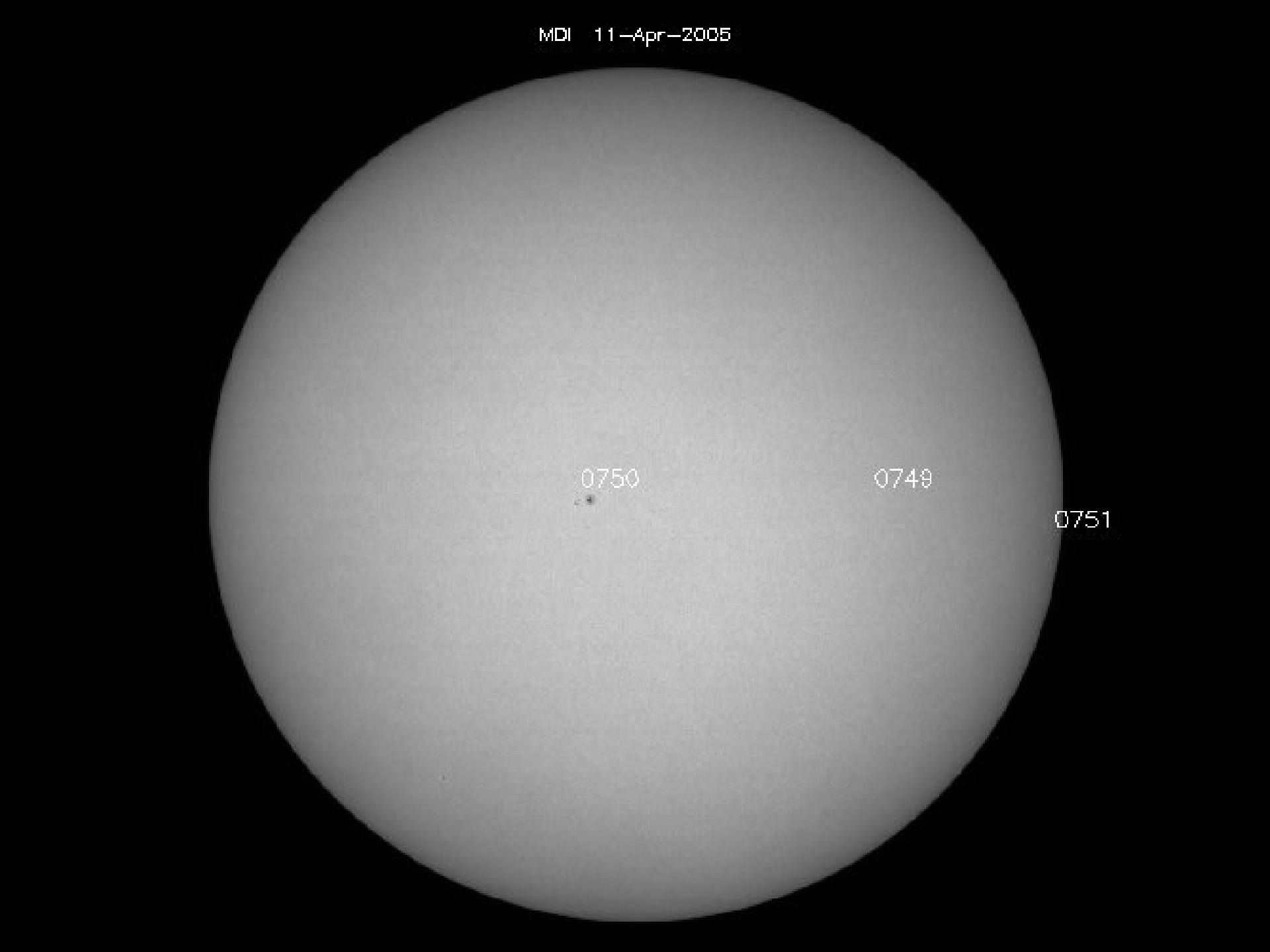


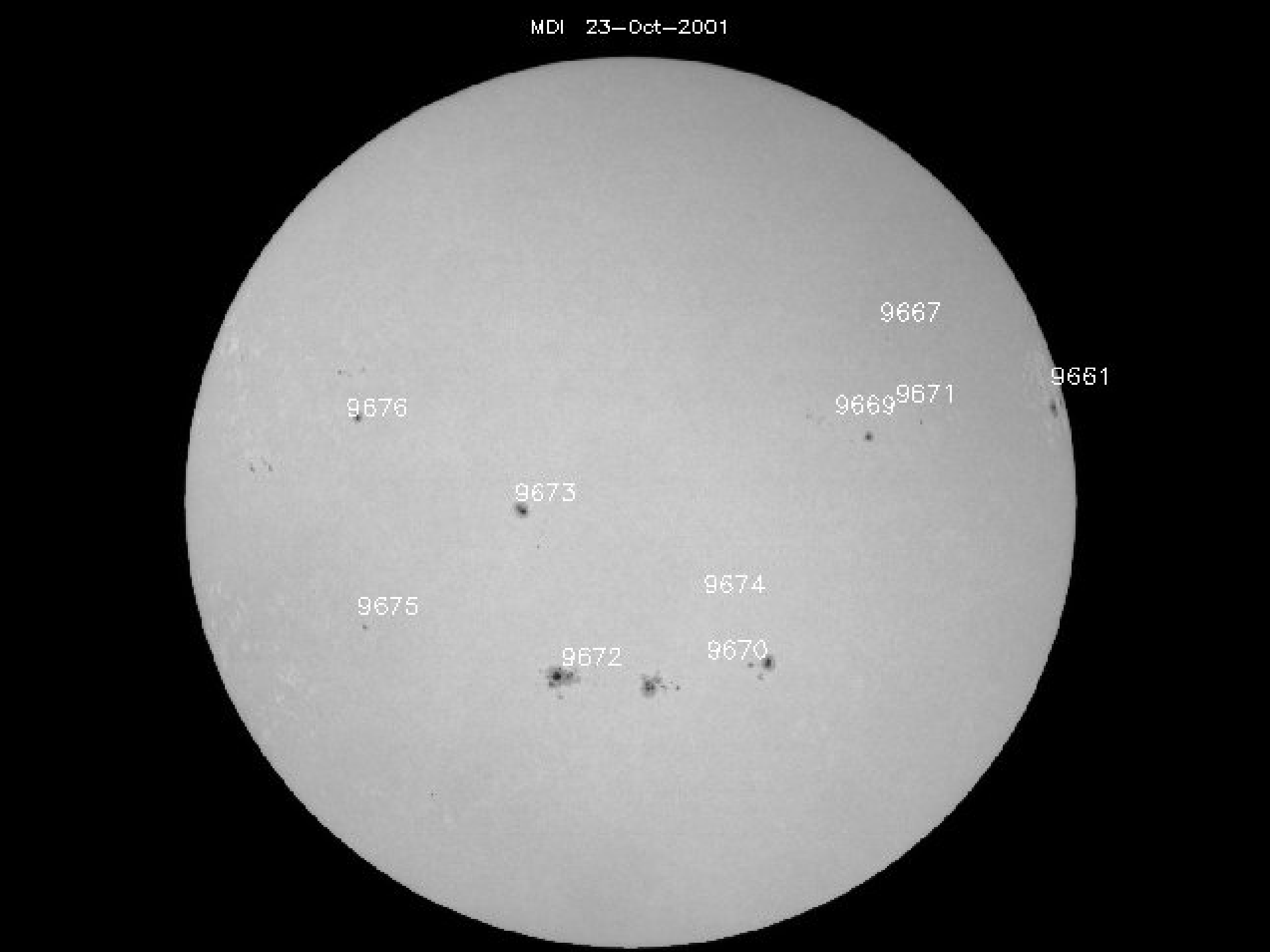
36 images in summer 1613

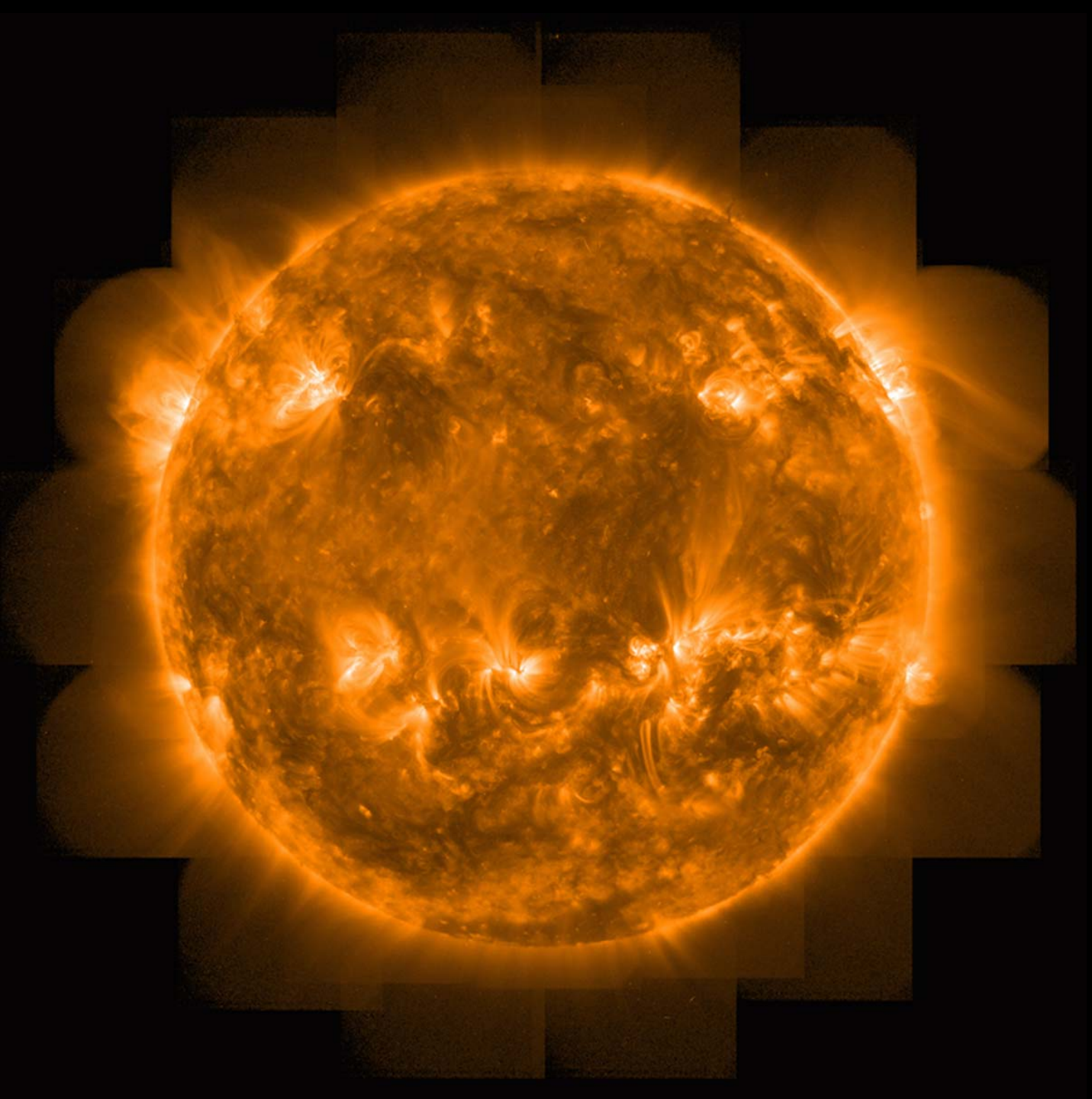
Sunspots




MONTHLY AVERAGE SUNSPOT NUMBER
300
200
100
0
1750
1760
1770
1780
1790
1800
1810
1820
1830
1840
DATE
1850
1860
1870
1880
1890
1900
1910
1920
1930
1940
DATE
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
DATE

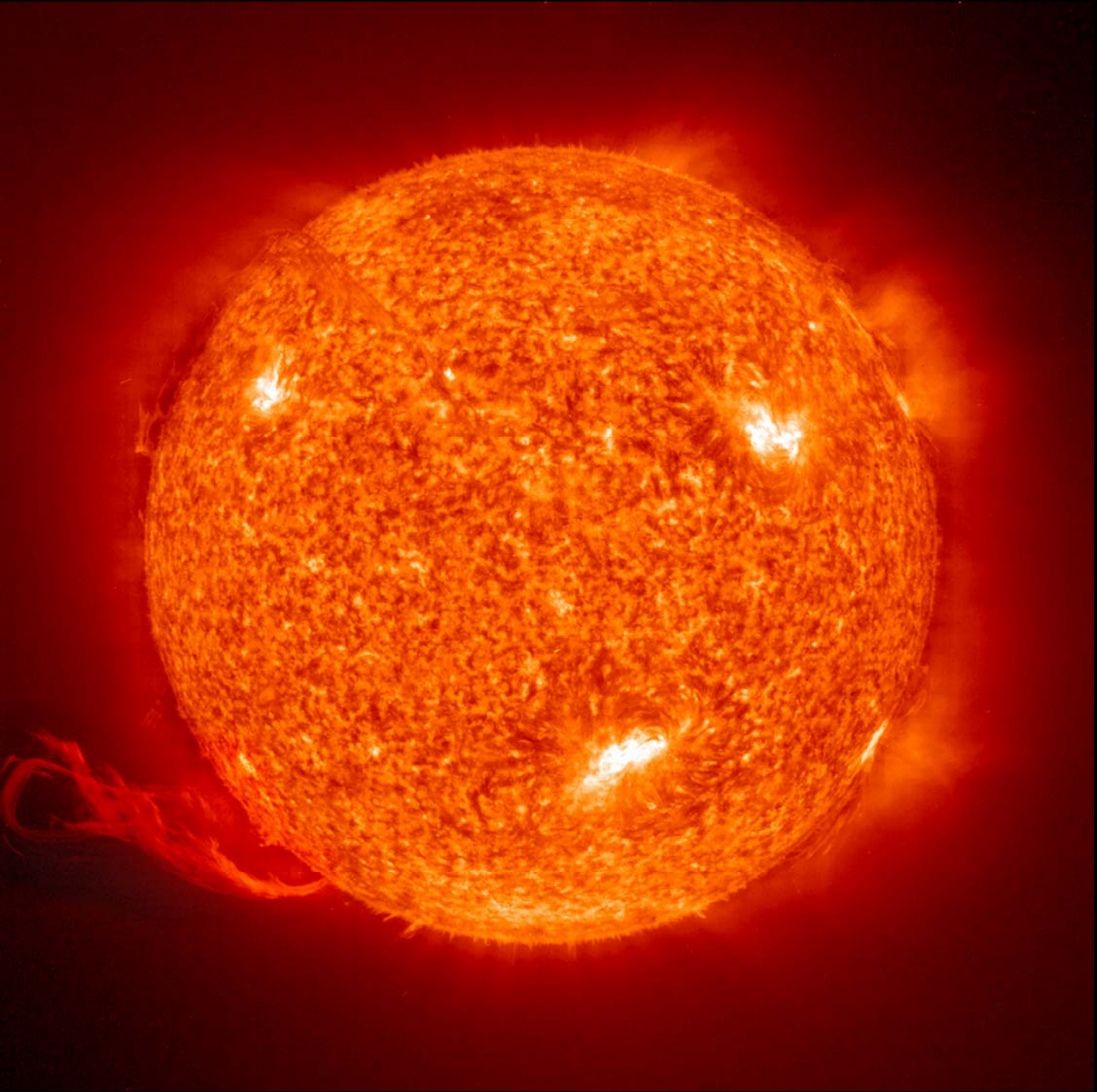

MDI 11-Apr-2005
0750
0749
0751


MDI 23-Oct-2001
9667
9661
9671
9669
9676
9673
9674
9675
9672
9670



Ultraviolet Light

TRACE (UV)



Solar Storms

Approximate Size of Earth

•

SOHO (UV)

Sun Websites with Pictures & Movies

http://cse.ssl.berkeley.edu/
http://sohowww.nascom.nasa.gov/
http://sunland.gsfc.nasa.gov/smex/trace/
http://es.rice.edu/ES/humsoc/Galileo/Things/g_sunspots.html

SIDEREVS NVNCIVS

MAGNA, LONGEQVE ADMIRABILIA
Spectacula pandens, suspiciendaque proponens
vnicuique, præsertim verò

PHILOSOPHIS, atq; ASTRONOMIS, quæ à

GALILEO GALILEO

PATRITIO FLORENTINO
Patauini Gymnasij Publico Mathematico

PERSPICILLI

Nuper à se reperti beneficio sunt obseruata in LVNÆ FACIE, FIXIS IN-NVMERIS, LACTEO CIRCVLO, STELLIS NEBVLOSIS,
Apprime verò in

QVATVOR PLANETIS
Circa IOVIS Stellam disparibus interuallis, atque periodis, celeritate mirabili circumuolutis; quos, nemini in hanc vsque diem cognitos, nouissimè Author depræhendit primus; atque

MEDICEA SIDERA

NVNCVPANDOS DECREVIT.

VENETIIS, Apud Thomam Baglionum. M DC X.
Superiorum Permissu, & Priuilegio.

SIDEREAL MESSENGER
unfolding great and very wonderful sights
and displaying to the gaze of everyone,
but especially philosophers and astronomers,
the things that were observed by
GALILEO GALILEI,
Florentine patrician
and public mathematician of the University of Padua, with the help of a
spyglass lately devised by him,
about the face of the Moon, countless fixed stars,
the Milky Way, nebulous stars,
but especially about
four planets
flying around the star of Jupiter at unequal intervals
and periods with wonderful swiftness;
which, unknown by anyone until this day,
the first author detected recently
and decided to name
MEDICEAN STARS

Ori. * *○ * Occ.

Stella occidentaliori maior, ambæ tamen valdè conspicuæ, ac splendidæ: vtra quæ distabat à Ioue scrupulis primis duobus; tertia quoque Stellula apparere cępit hora tertia prius minimè conspecta, quæ ex parte orientali Iouem ferè tangebat, eratque admodum exigua. Omnes fuerunt in eadem recta, & secundum Eclypticæ longitudinem coordinatæ.

Die decimatertia primum à me quatuor conspectæ fuerunt Stellulæ in hac ad Iouem constitutione. Erant tres occidentales, & vna orientalis; lineam proximè

Ori. * ○ * * * Occ.

rectam constituebant; media enim occidẽtalium paululum à recta Septentrionem versus deflectebat. Aberat orientalior à Ioue minuta duo: reliquarum, & Iouis intercapedines erant singulæ vnius tantum minuti. Stellæ omnes eandem præ se ferebant magnitudinem; ac licet exiguam, lucidissimæ tamen erant, ac fixis eiusdem magnitudinis longe splendidiores.

Die decimaquarta nubilosa fuit tempestas.

Die decimaquinta, hora noctis tertia in proximè depicta fuerunt habitudine quatuor Stellæ ad Iouem;

Ori. ○ * * * * Occ.

occidentales omnes: ac in eadem proxim recta linea dispositæ; quæ enim tertia à Ioue numerabatur paululum

lulum in boream attollebatur; propinquior Ioui erat omnium minima, reliquæ consequenter maiores apparebant; interualla inter Iouem, & tria consequantia Sydera erant æqualia omnia, ac duorum minutorum: at occidentalius aberat à sibi propinquo minutis quatuor. Erant lucida valde, & nihil scintillantia, qualia semper tum ante, tum post apparuerunt. Verum hora septima tres solummodo aderant Stellæ, in huiusce modi cum Ioue aspectu; Erant nempe in eadem recta ad vnguem, vicinior Ioui, erat admodum exigua, & ab illo semota per minuta prima tria; ab hac secunda distabat min: vno; tertia verò à secunda min: pr: 4. sec: 30. Post verò aliam horam duæ Stellulæ mediæ adhuc viciniores erant; aberant enim min: sc: vix 30. tantum.

Ori. ○ * * * Occ.

Die decimasexta hora prima noctis tres vidimus Stellas iuxta hunc ordinem dispositas. Duæ Iouem

Ori. *○* * Occ.

intercipiebant ab eo per min: 0. sec: 40. hincinde remotæ, tertia verò occidentalis à Ioue distabat min: 8. Ioui proximæ non maiores, sed lucidiores apparebant remotiori.

Die decimaseptima hora ab occasu 0. min: 30. huiusmodi fuit configuratio. Stella vna tantum orientalis à

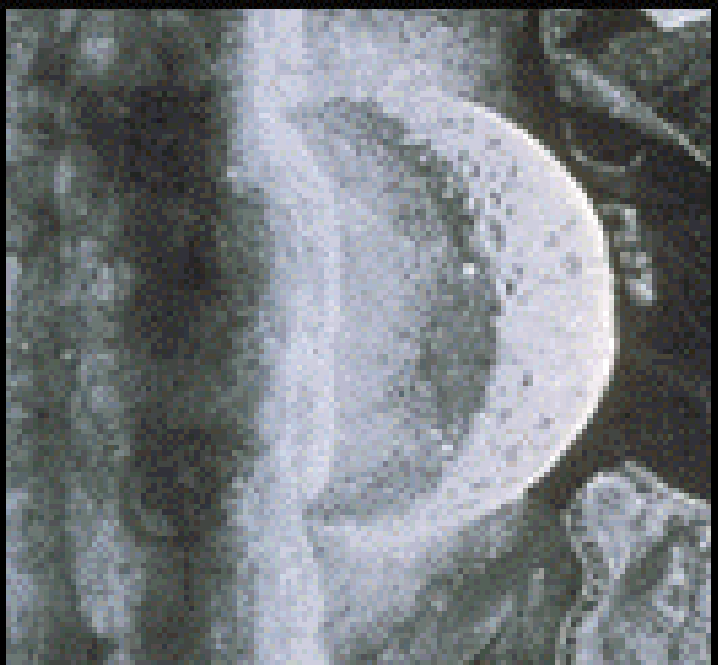
Ori. * ○ * Occ.

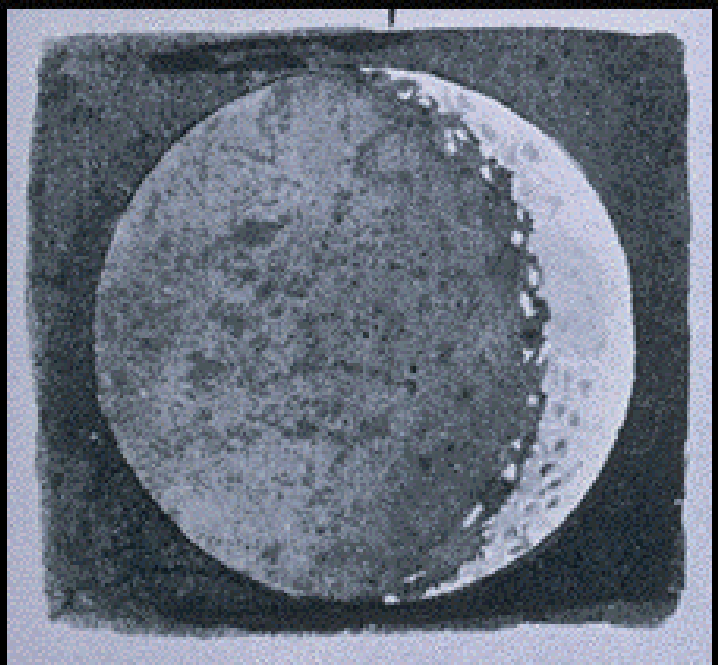
Ioue

Assumption of the Virgin
(1610-1612)

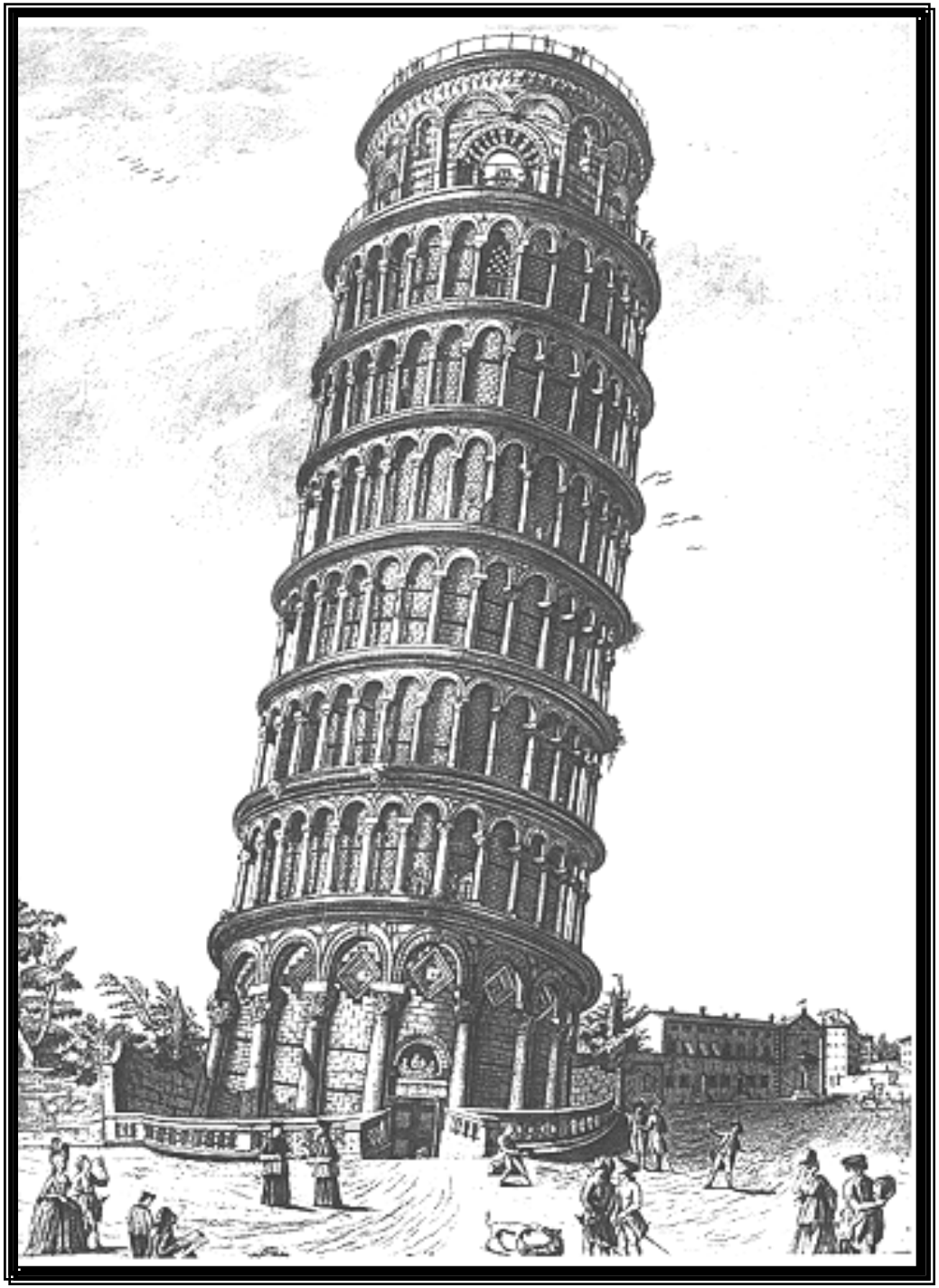
Lodovico Cigoli
Santa Maria Maggiore

Siderius Nuncius
Galileo 1608





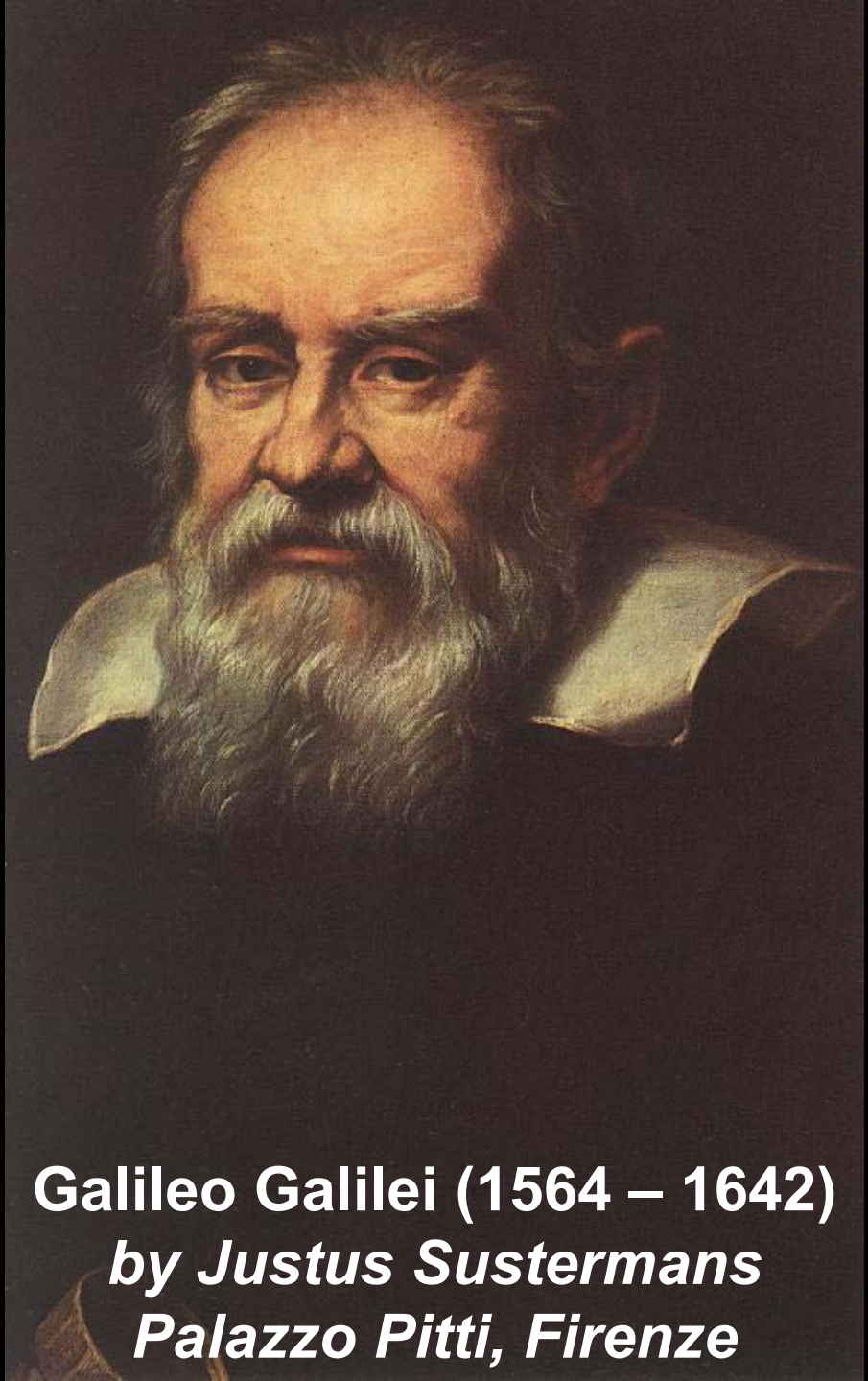
You cannot help it, Signor Sarsi [a pseudonym of Grassi] , that it was granted to me alone to discover all the new phenomena in the sky and nothing to anybody else. This is the truth which neither malice nor envy can suppress.



The Greatest Book!

Philosophy is written in this grand book, the universe, which stands continually open to our gaze. But the book cannot be understood unless one first learns to comprehend the language and read the letters in which it is composed. It is written in the language of mathematics, ….

Il Saggiatore



Galileo Galilei (1564 – 1642)
by Justus Sustermans
Palazzo Pitti, Firenze

1. **The sun is the center of the world [solar system or universe] and altogether immovable in local motion.**

2. **Earth is not the center of the world and not immovable, but moves as a whole and also with diurnal motion [spins on its axis].**

Maffeo Barberini
(1568 - 1644)

Urban VIII
(1623 - 1644)

Caravaggio 1599
Private Collection, Firenze

DIALOGO
DI
GALILEO GALILEI LINCEO
MATEMATICO SOPRAORDINARIO

DELLO STVDIO DI PISA.

E Filosofo, e Matematico primario del

SERENISSIMO

GR. DVCA DI TOSCANA.

Doue ne i congressi di quattro giornate si discorre sopra i due

MASSIMI SISTEMI DEL MONDO
TOLEMAICO, E COPERNICANO:

Proponendo indeterminatamente le ragioni Filosofiche, e Naturali tanto per l'vna, quanto per l'altra parte.

CON PRI VILEGI.

IN FIORENZA, Per Gio: Batista Landini MDCXXXII.

CON LICENZA DE' SVPERIORI.

Imprimatur si videbitur Reuerendiss. P. Magistro Sacri Palatij Apostolici.
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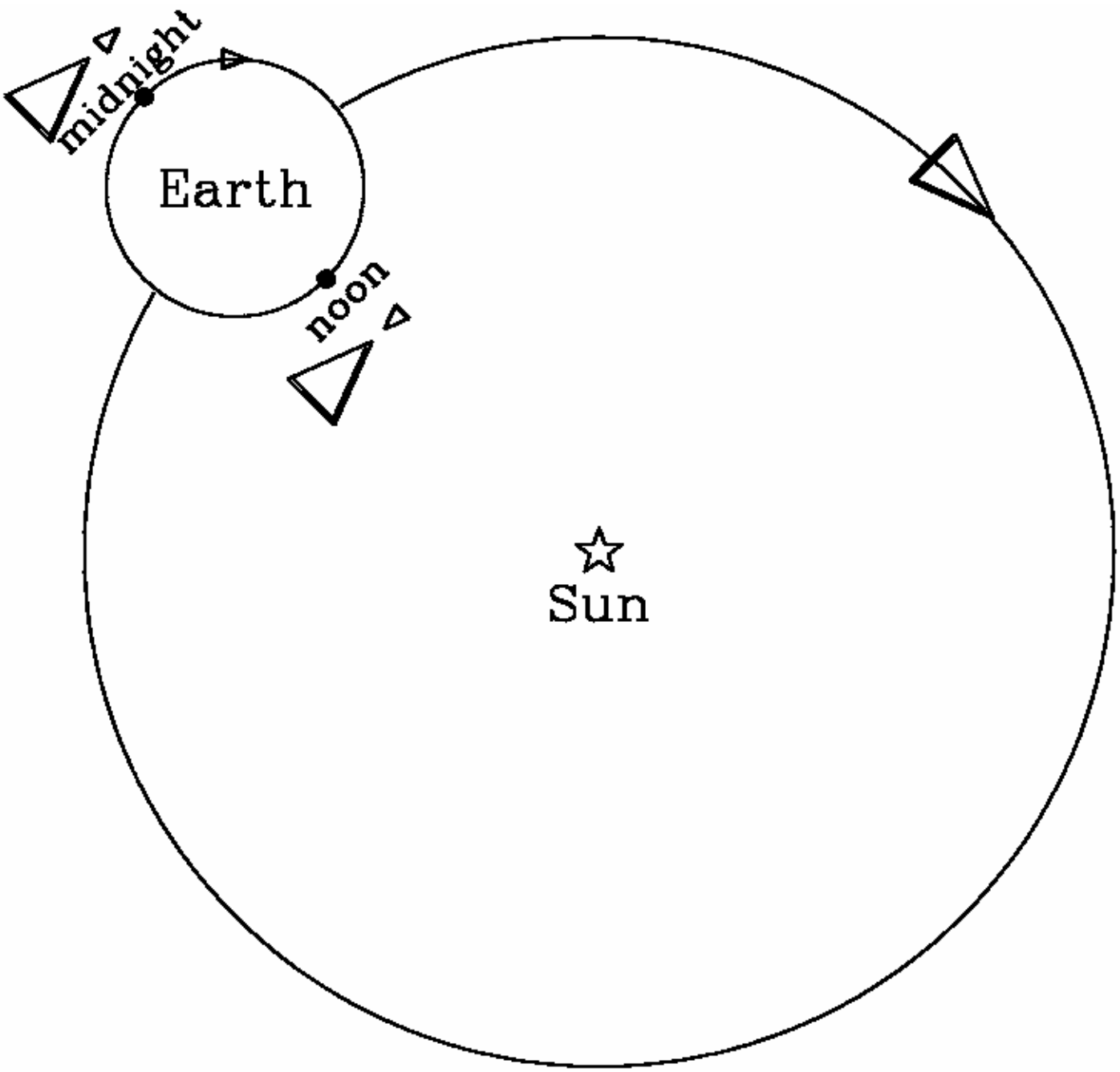

midnight
Earth
noon
Sun

Take note, theologians, that in your desire to make matters of faith out of propositions relating to the fixity of the Sun and Earth you run the risk of eventually having to condemn as heretics those who would declare the Earth to stand still and the Sun to change position---eventually, I say, at such a time as it might be physically or logically proved that the Earth moves and the Sun stands still.

Note added by Galileo
in the preliminary leaves of
his own copy of The Dialogue*.*

From the dedication of the Dialogue:

Most Serene Grand Duke:

Though the difference between man and the other animals is enormous, yet one might reasonably say that it is little less than the difference among men themselves. ….

I believe the constitution of the universe may be set in first place among all natural things that can be known, for coming before all others in grandeur by reason of its universal content, it must also stand above them all in nobility as their rule and standard. ….

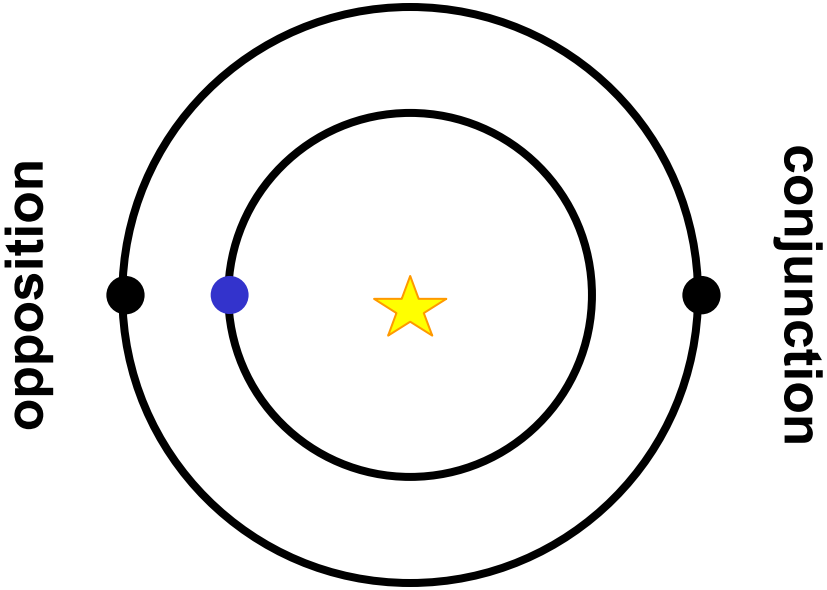
... that I once heard from a most eminent and learned person, and before which one must fall silent. I know that if asked whether God in his infinite power and wisdom could have conferred upon the watery element its observed reciprocating motion using some other means than moving its containing vessels, both of you would reply that He could have, and He would have known how to do this in many ways which are unthinkable to our minds. From this I forthwith conclude that, this being so, it would be excessive boldness for anyone to limit and restrict the Divine power and wisdom to some particular fancy of his own.

I do not feel obliged to believe that the same God who has endowed us with sense, reason, and intellect has intended us to forego their use.

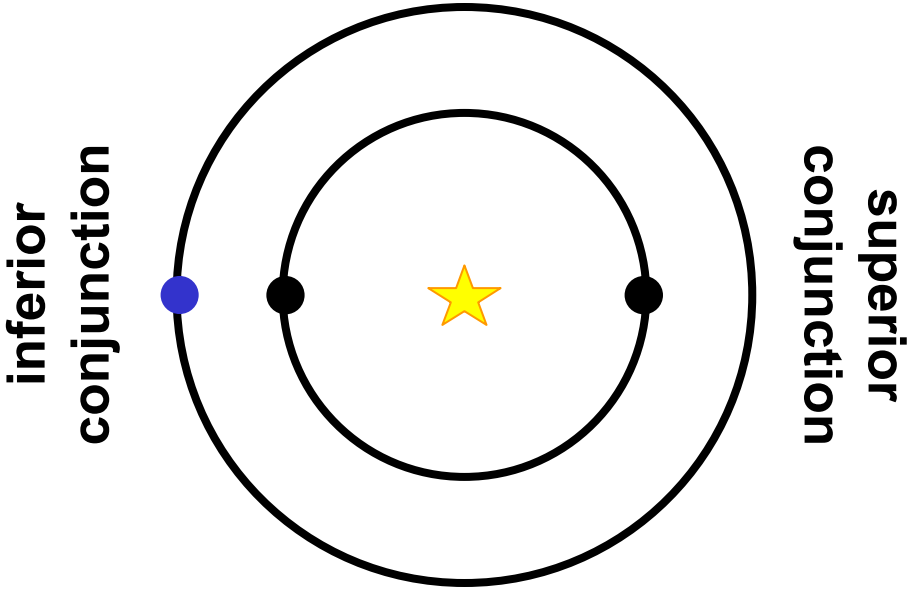
Galileo

Opposition and Conjunction

superior planet



inferior planet

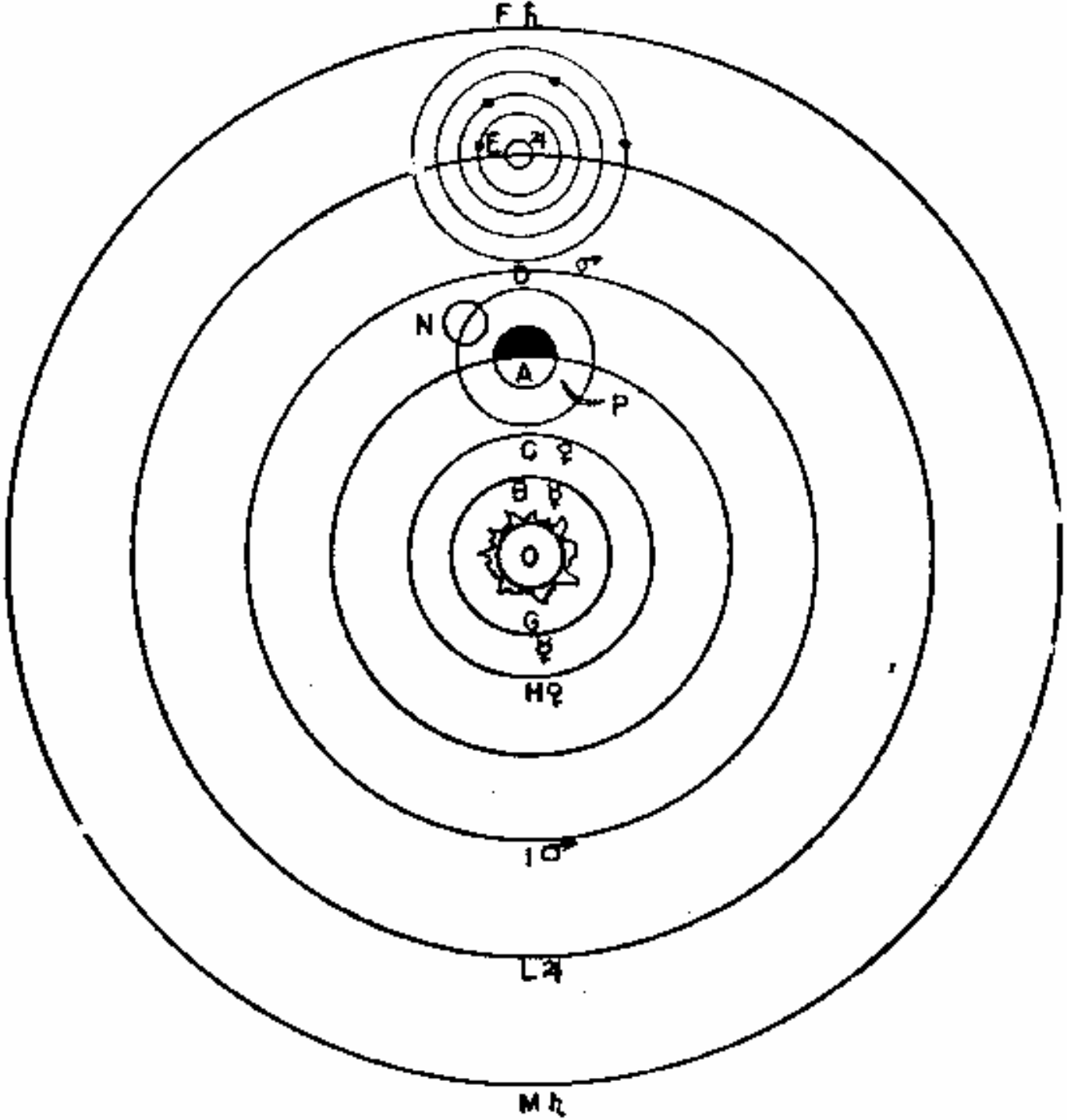


Rocky Kolb Productions Presents

The Dialogue Concerning the Two Chief World Systems

April 11, 2006

Salviati: Alexia Koelling
Sagredo: Lija Bentley-Phillips
Simplicio: Heath Blackerby


F ♄
E ♃
♂
N
A
P
C ♀
B ☿
O
G
☿
H ♀
I ♂
L ♃
M ♄

“The subject of origins will be discussed in a balanced manner if it is discussed at all. I see nothing illiberal about such a requirement, nor can I imagine Gallileo (sic) or Einstein would have found fault with it.”

Honorable Thomas Gibbs Gee
US 5th Circuit Court of Appeals
Minority (5-4) Opinion overturning
Louisiana Creation Science Law

1613: Letters to Castelli and Christina

1615: Bellarmine wrote Galileo, advised him
Copernicus should be thought of as a <u>hypothesis</u>

1615-1616: Galileo learned he was “under suspicion”

1616: Galileo went to Rome-disaster
Father theologians: Earth doesn’t move, involves heresy
Paul V ordered Bellarmine to warn Galileo

1623: Barberini $\rightarrow$ Urban VIII

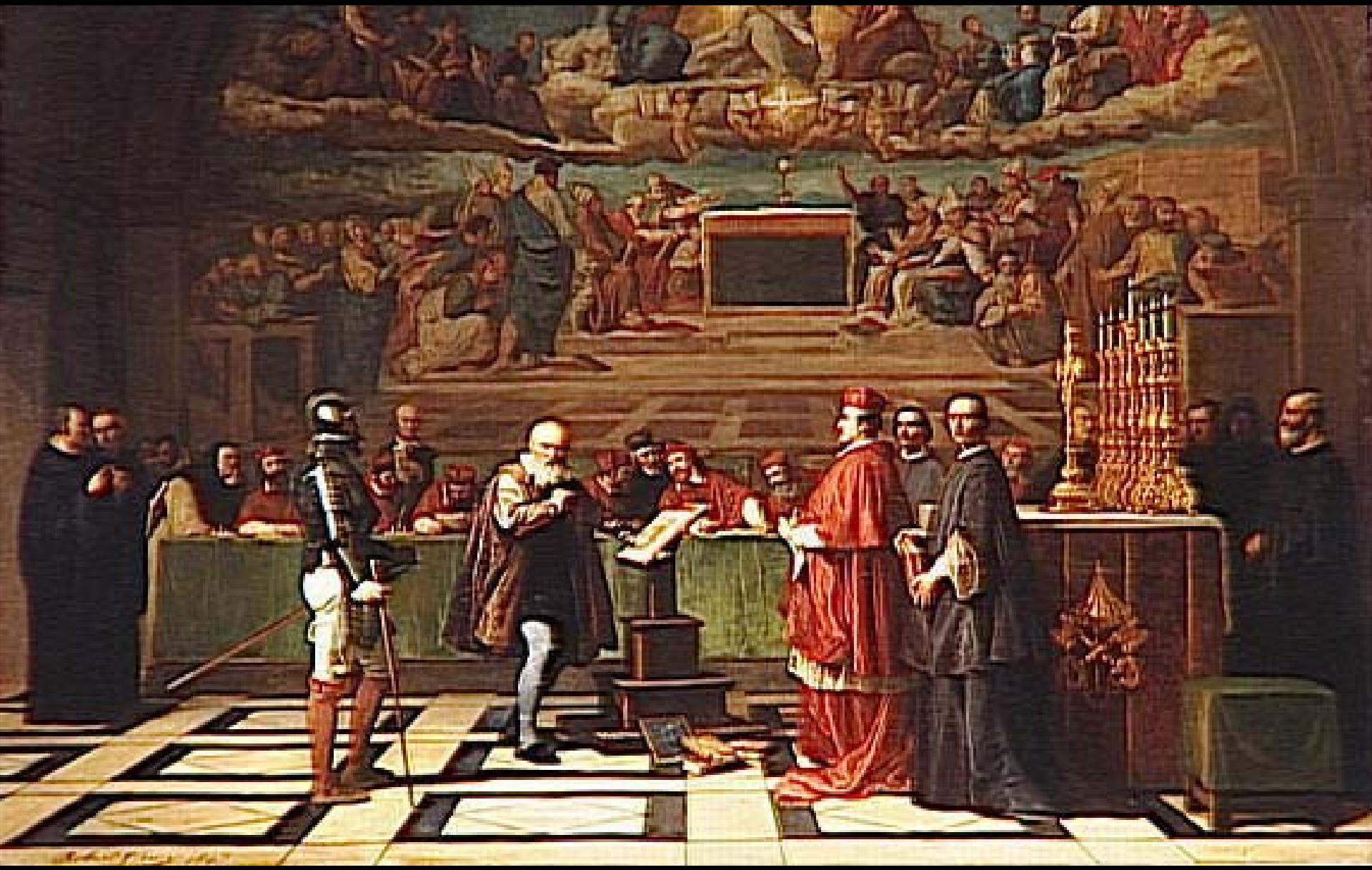
1624: Galileo travels to Rome-6 audiences with Urban

1630: Galileo finishes *Dialog*

1632: *Dialog* is published-5 months later banned

1633: Galileo faces Inquisition

Napoleon, by Jacques Louis David 1801



The Trial of Galileo, Robert Fleury, Musée du Louvre

Santa Maria Sopra Minerva

Maffeo Barberini
(1568 - 1644)

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