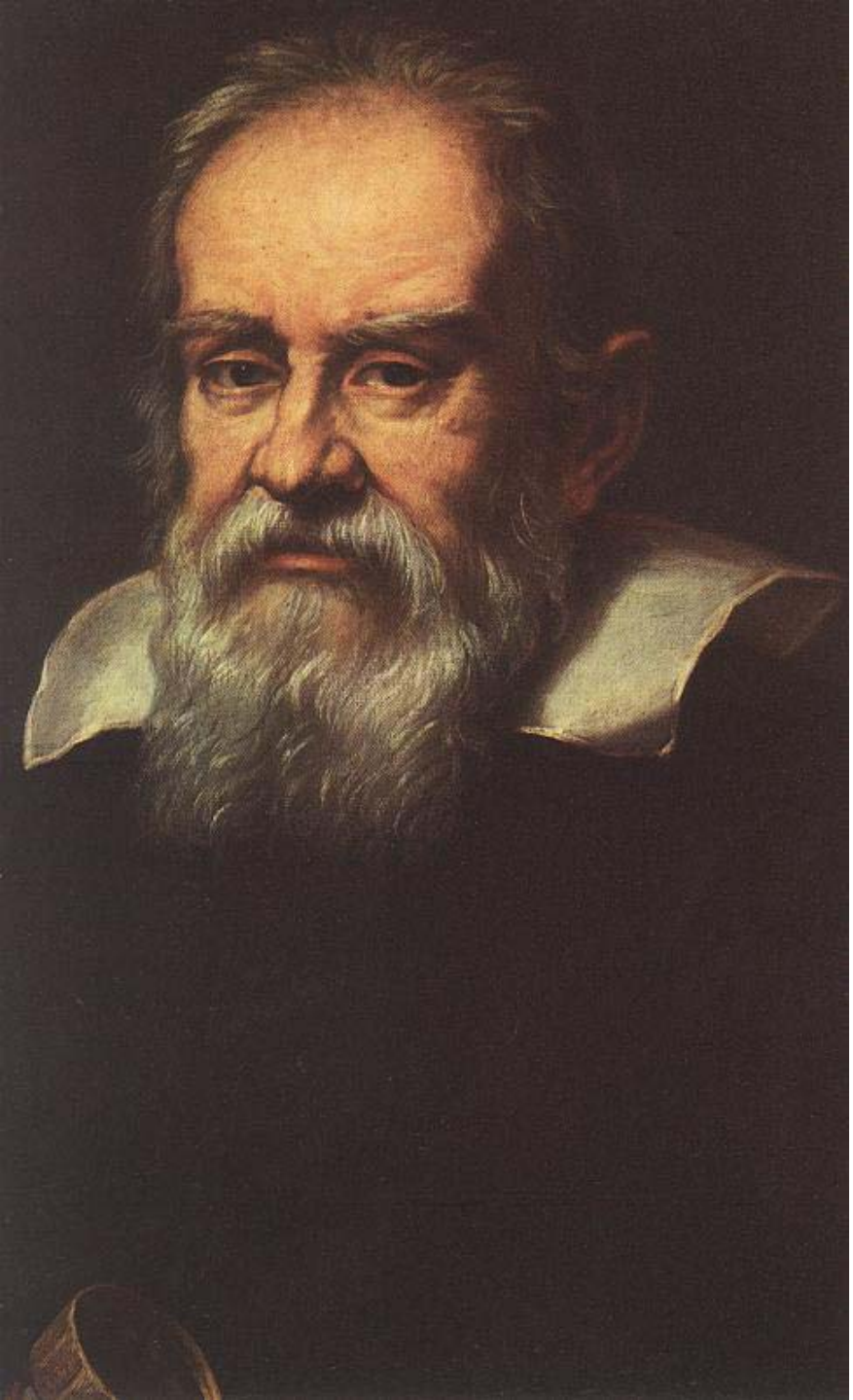


NS 102
Lecture 5
April 12, 2005

Opening: Mozart Symphony #41
(Jupiter) in C-major K551
4th movement *molto allegro*

Closing: Drops of Jupiter
Train

Galileo Galilei
1564 – 1642

by
Justus Sustermans
Palazzo Pitti
Firenze

GnatSigh News

(all the news that fits)

- http://home.fnal.gov/~rocky/NS102/
- Labs: 2nd week of moons of Jupiter
- Homework due at start of class

Rocky Kolb-GnatSigh Productions Presents

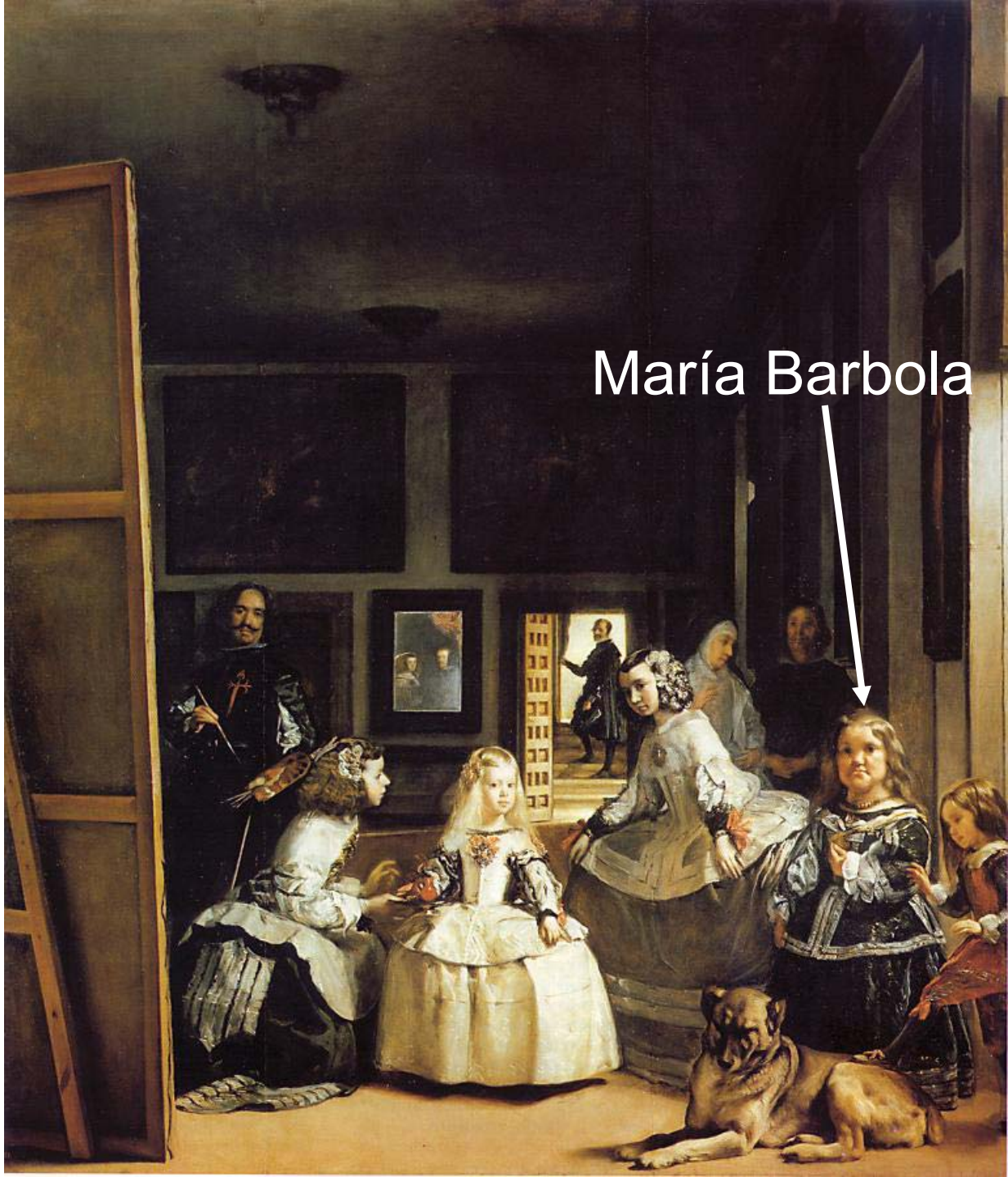
The Dialogue Concerning the Two Chief World Systems

April 14, 2005

Salviati: Vanessa Tantillo
Sagredo: Talia Gorodess
Simplicio: Jeff Eisenberg

I Fantasmi: Alberto Vallinotto
Michele Liguori
Matteo Fasiello

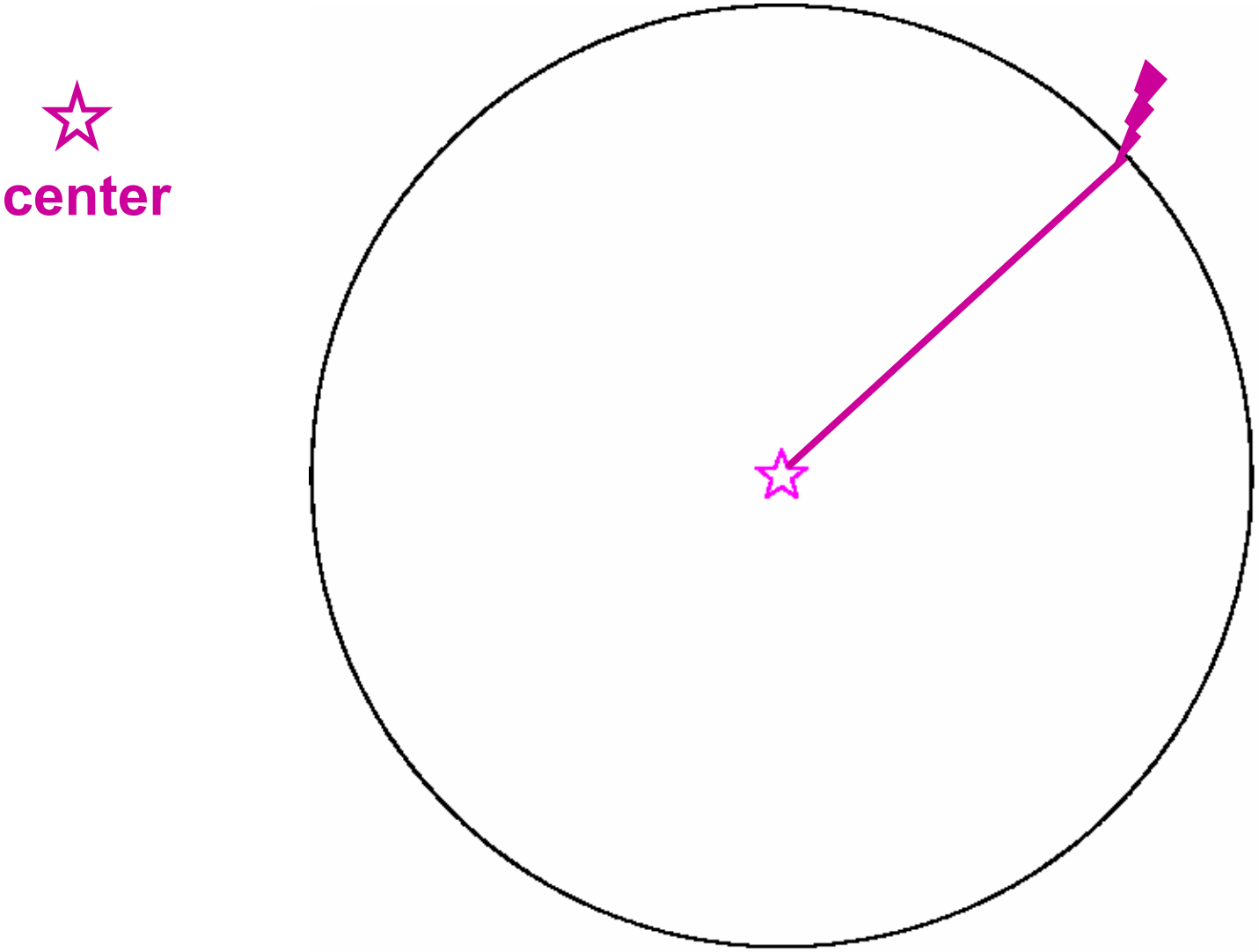
FAMILY OF PHILIP IV
OR
"LAS MENINAS" (1656)
Diego Velázquez de Silva
(1599-1660)



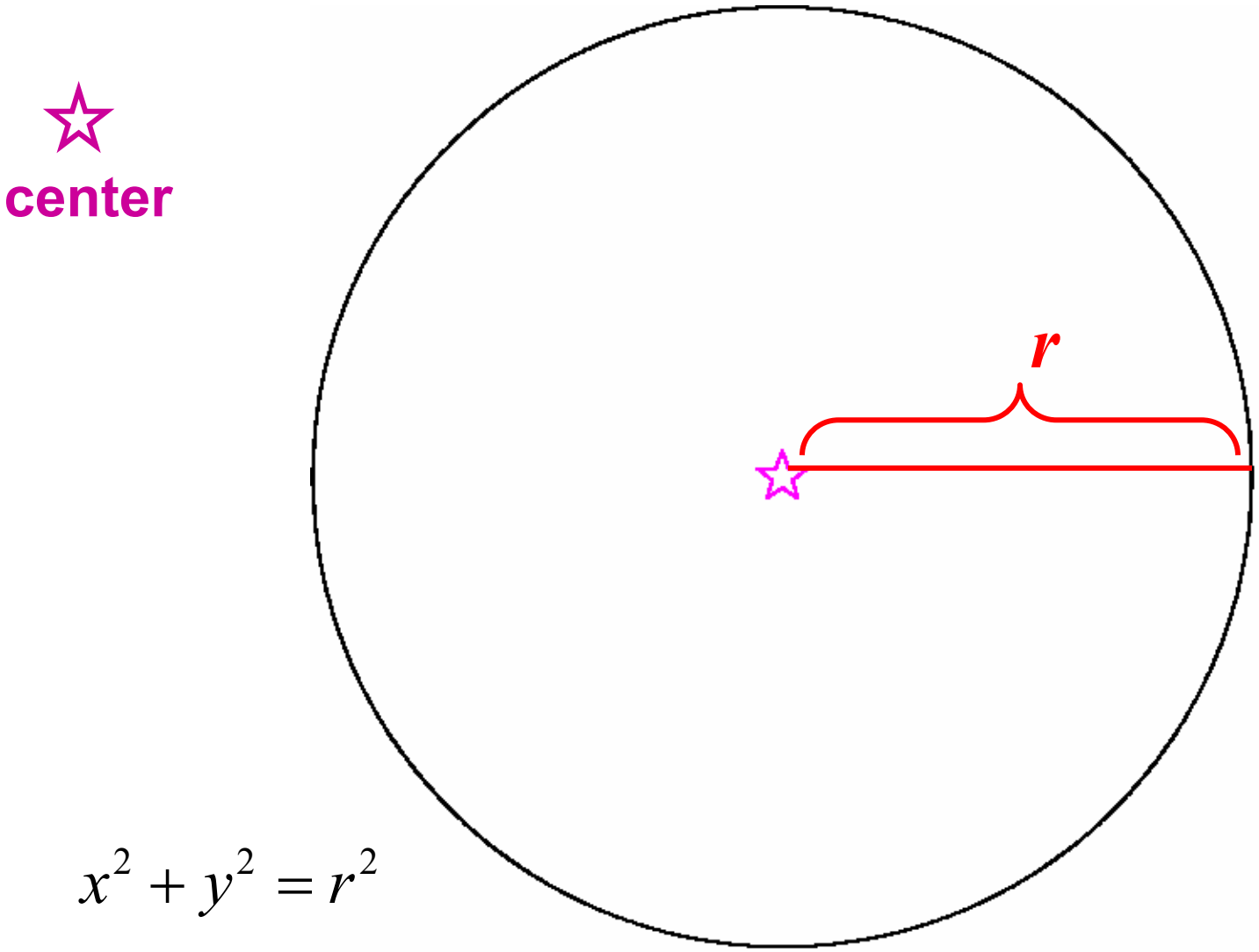
Stanza di Constantino Raphael's Workshop
(Giulio Romano, ca. 1520)

Kepler's 1st Law

circle

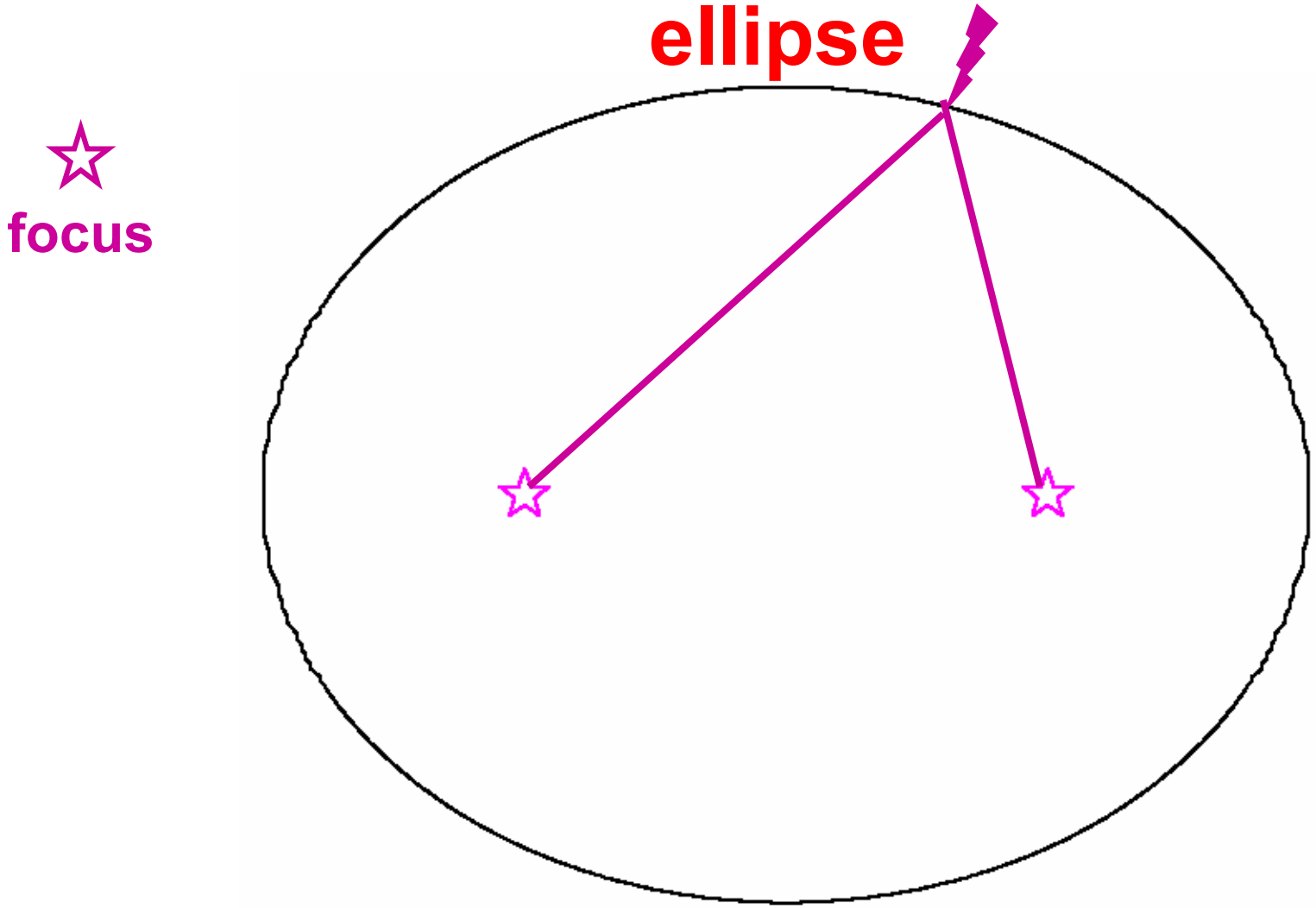


circle

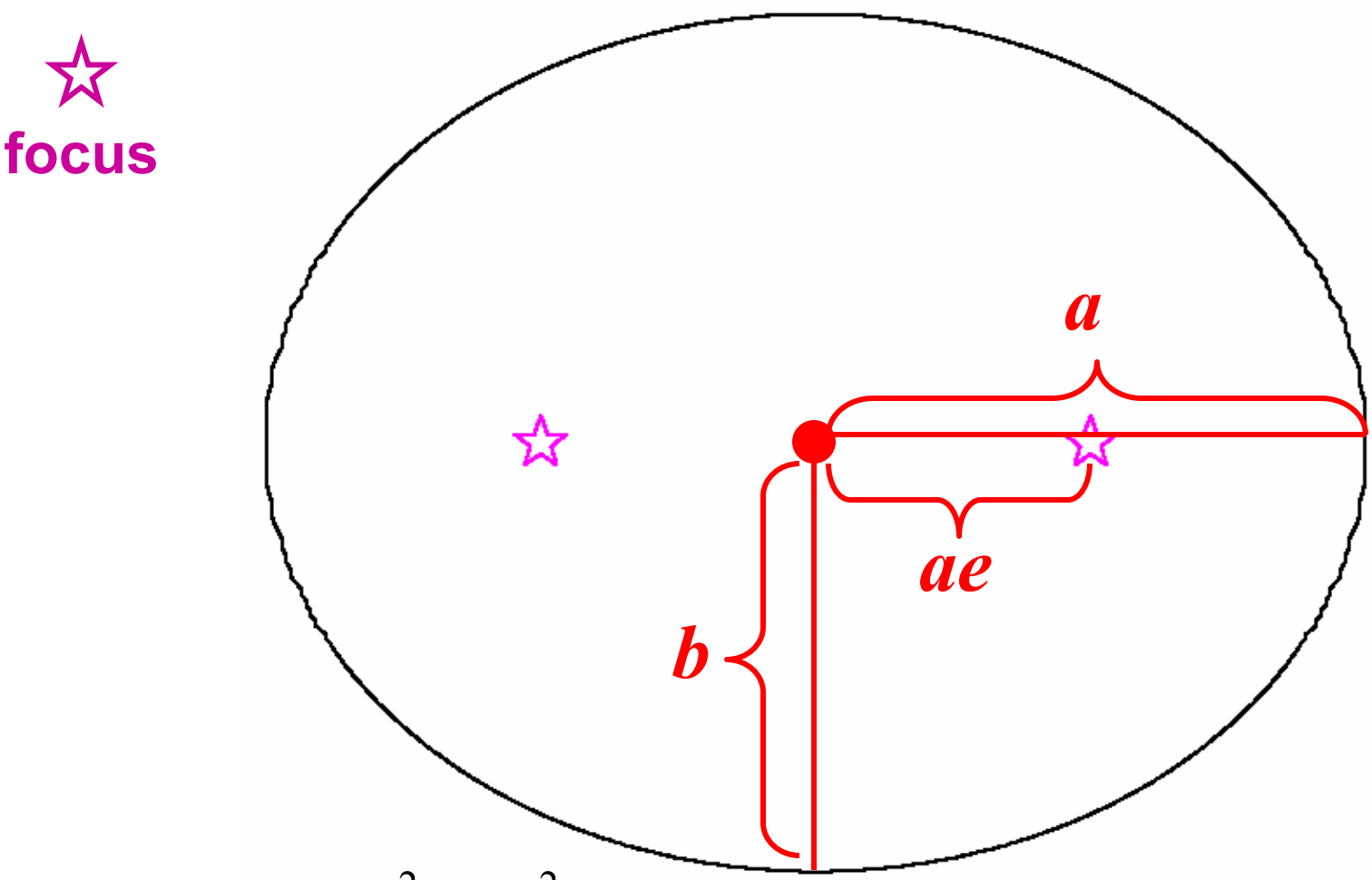


$$x^2 + y^2 = r^2$$

$$\frac{x^2}{r^2} + \frac{y^2}{r^2} = 1 \qquad r^2 > 0$$


ellipse
focus

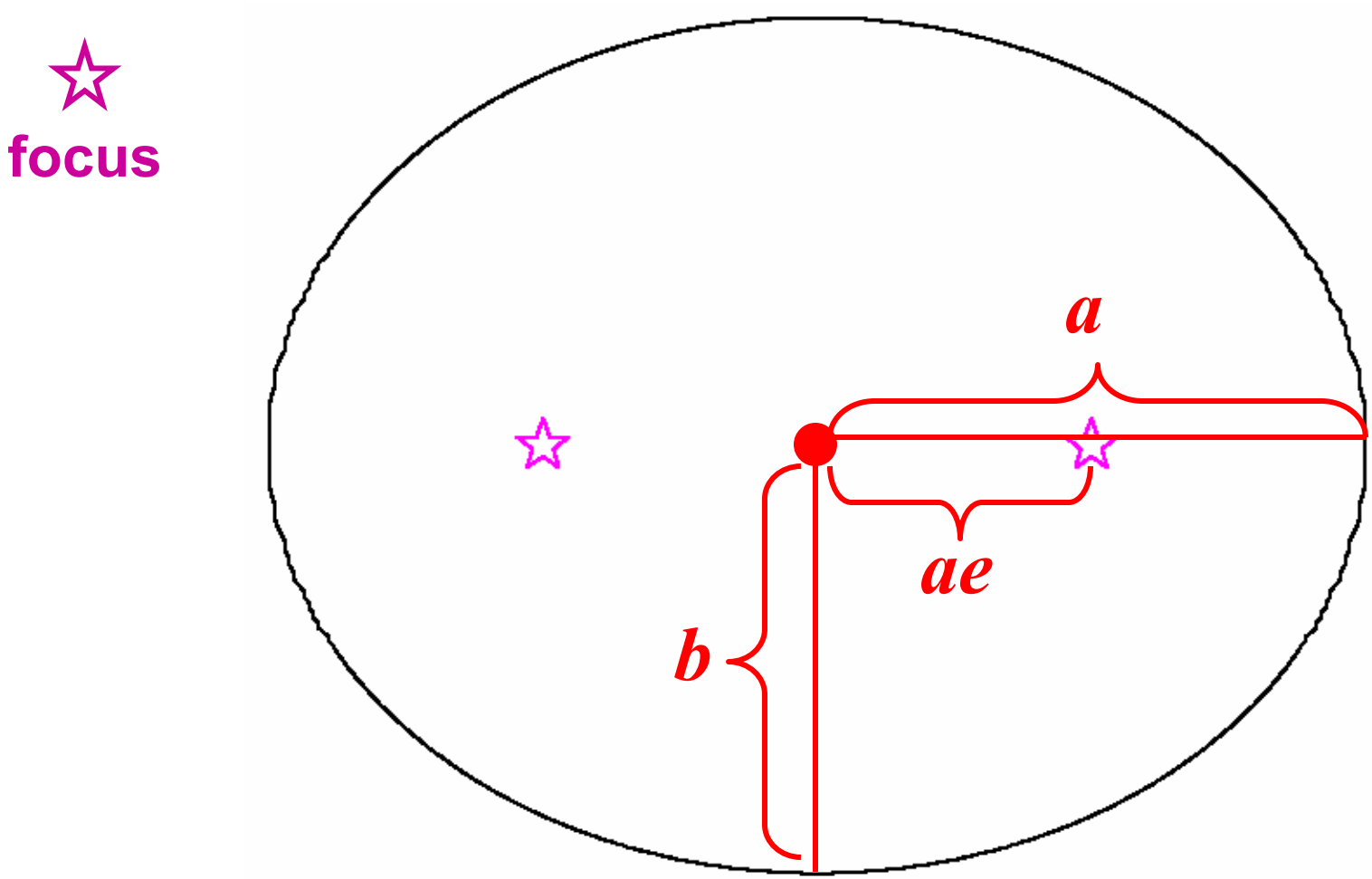
ellipse



$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1 \qquad a > b > 0$$

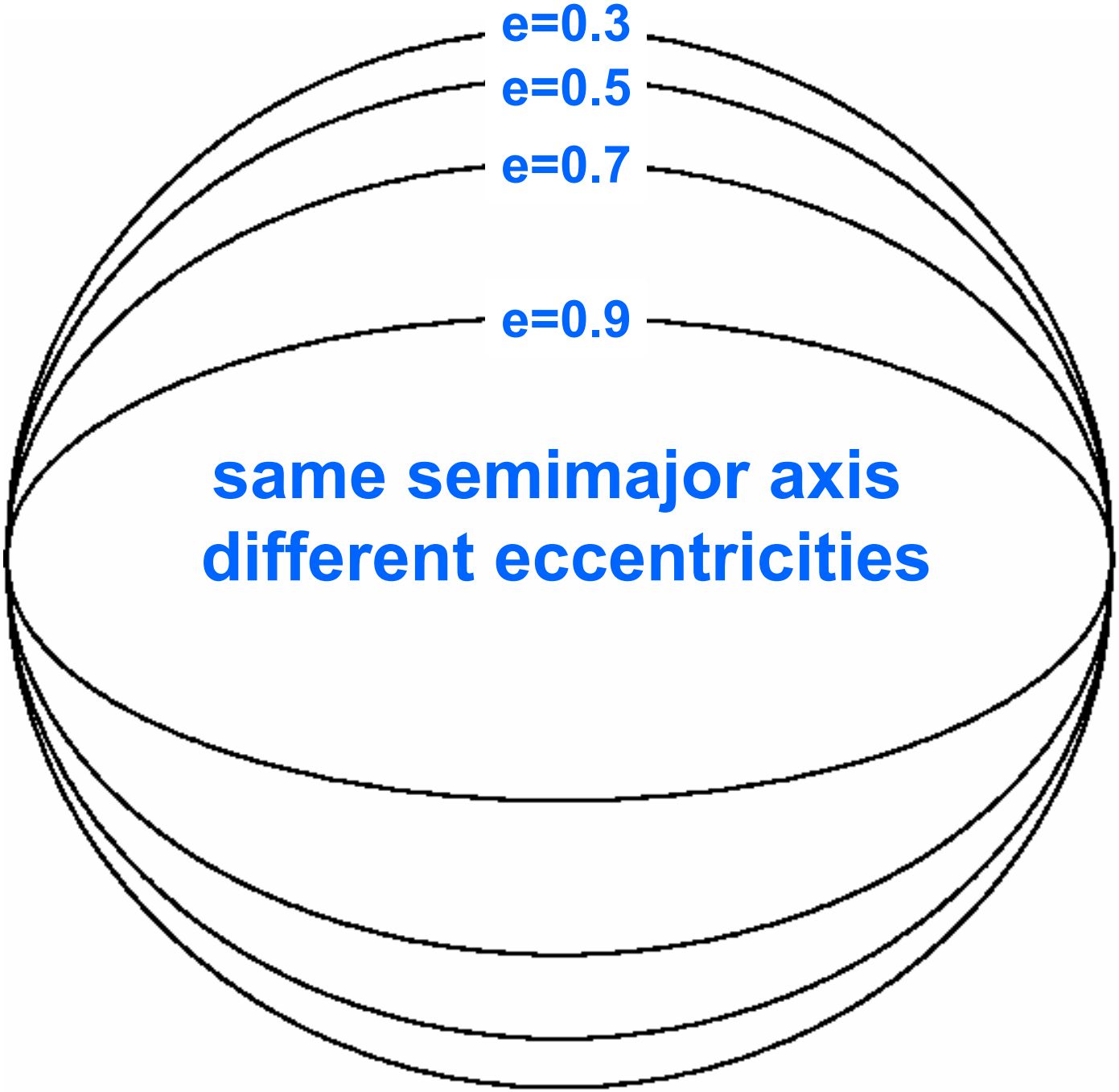
eccentricity $e = \sqrt{1^2 - b^2 / a^2} = 0.5$

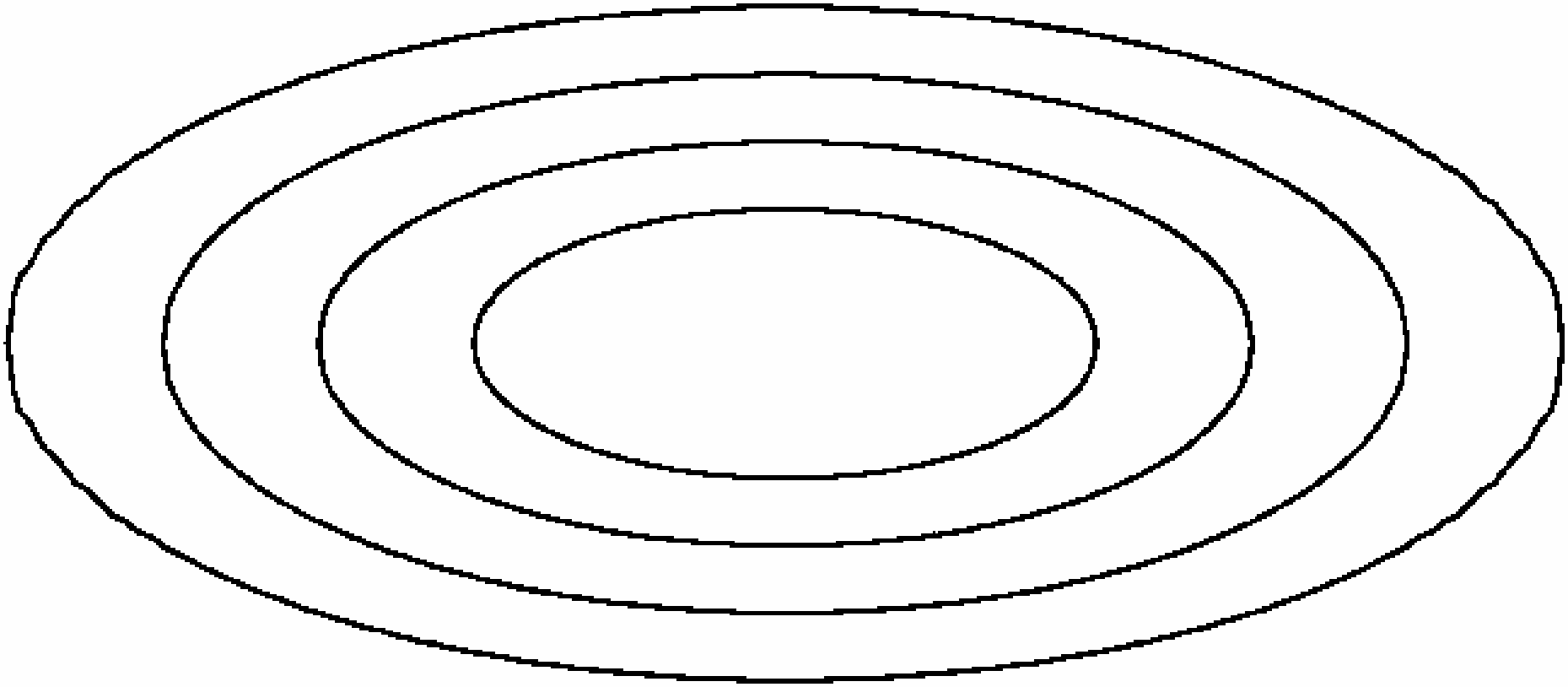
ellipse



eccentricity $e = \sqrt{1 - b^2/a^2} = 0.5$

$b/a = \sqrt{1-e^2} \simeq 1 - \frac{1}{2}e^2$ for e small

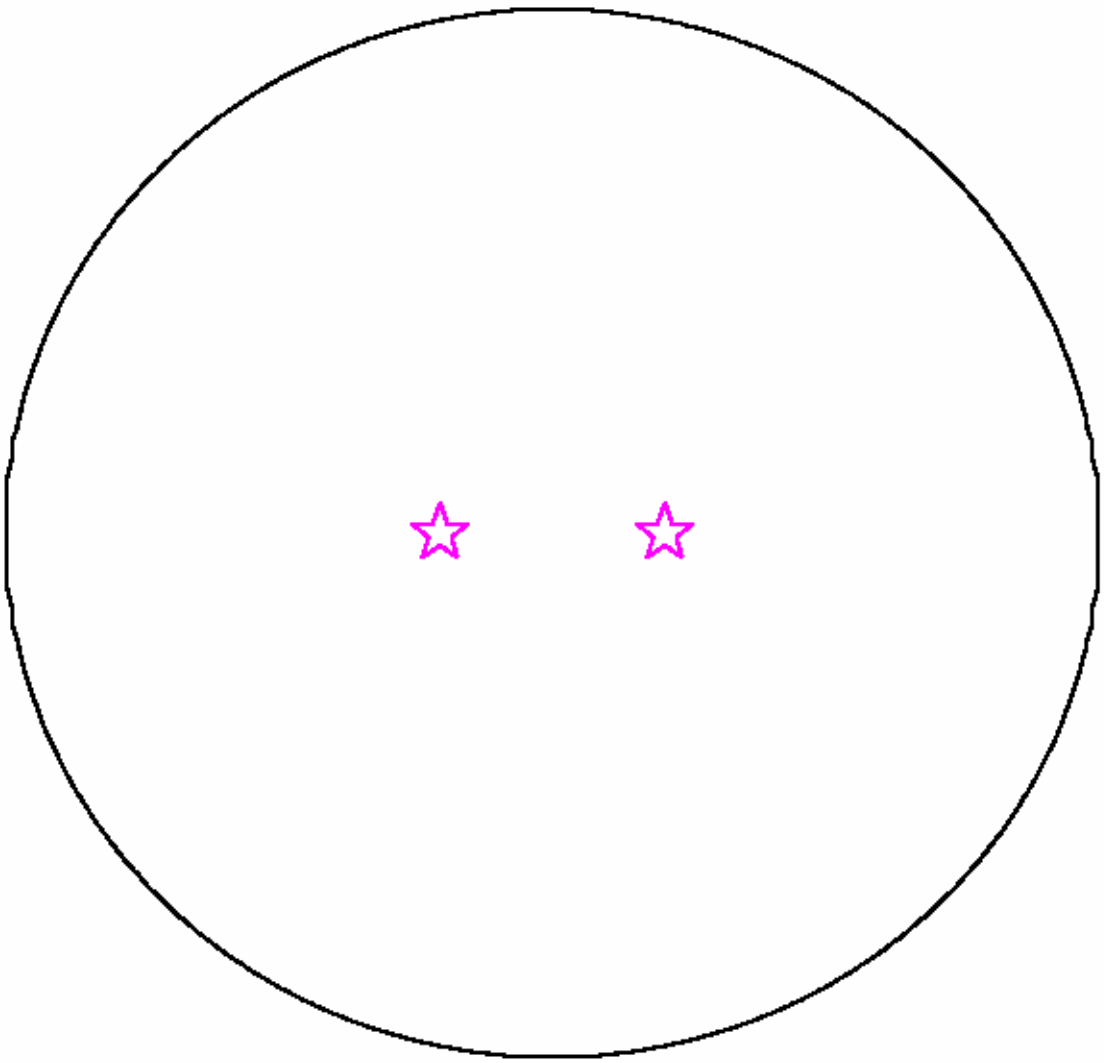

e=0.3
e=0.5
e=0.7
e=0.9
same semimajor axis
different eccentricities



same eccentricity

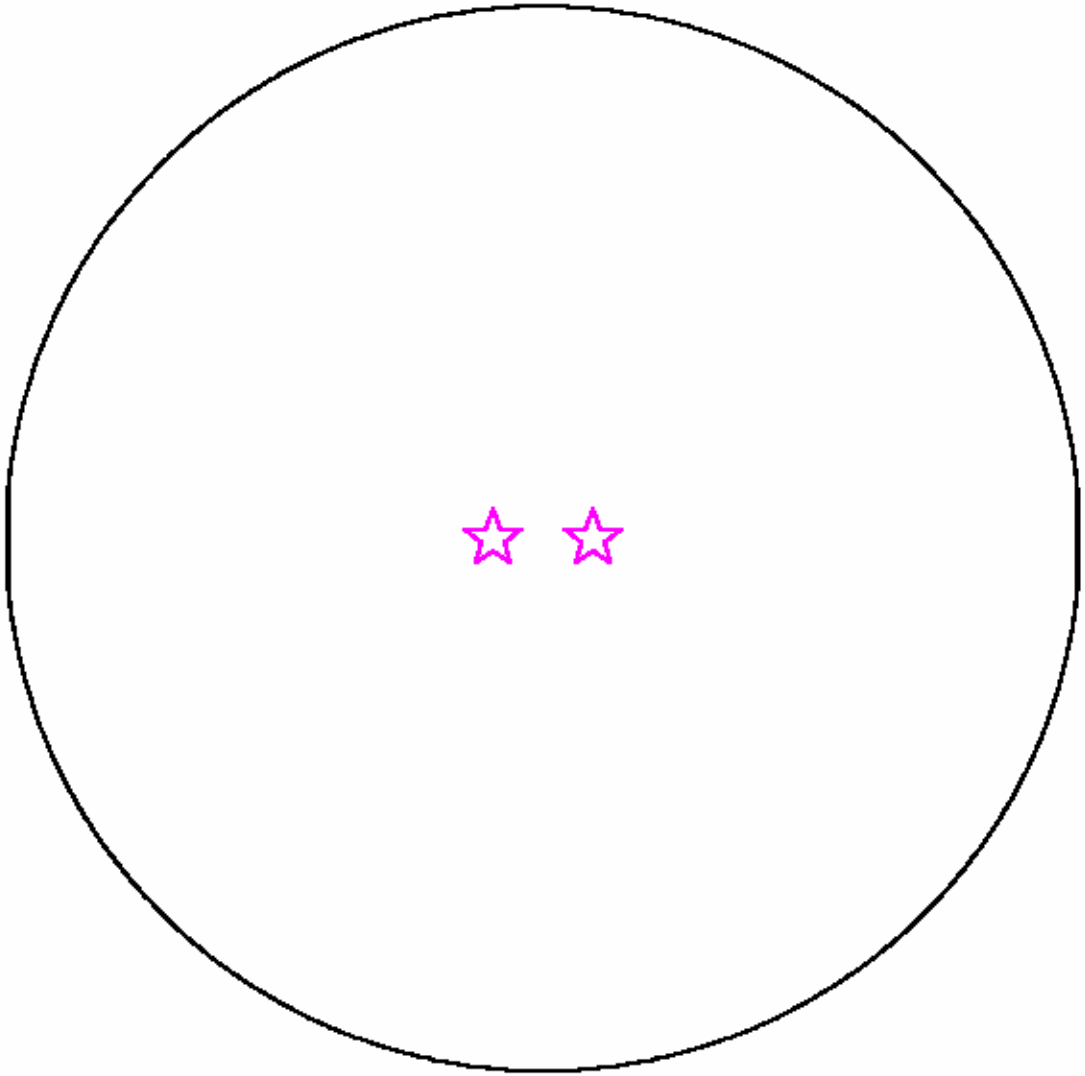
different semimajor axis

Mercury

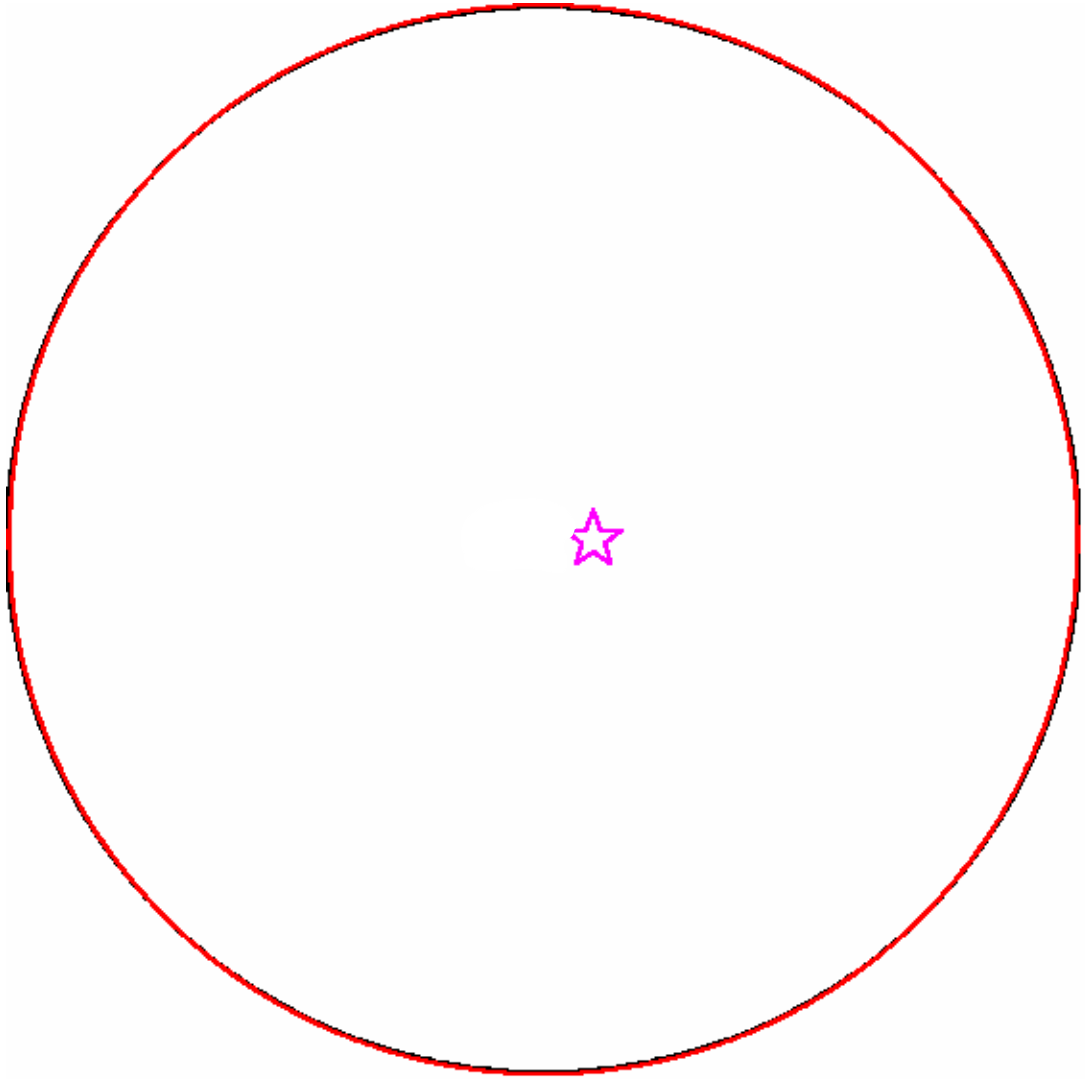


eccentricity = 0.2

Mars

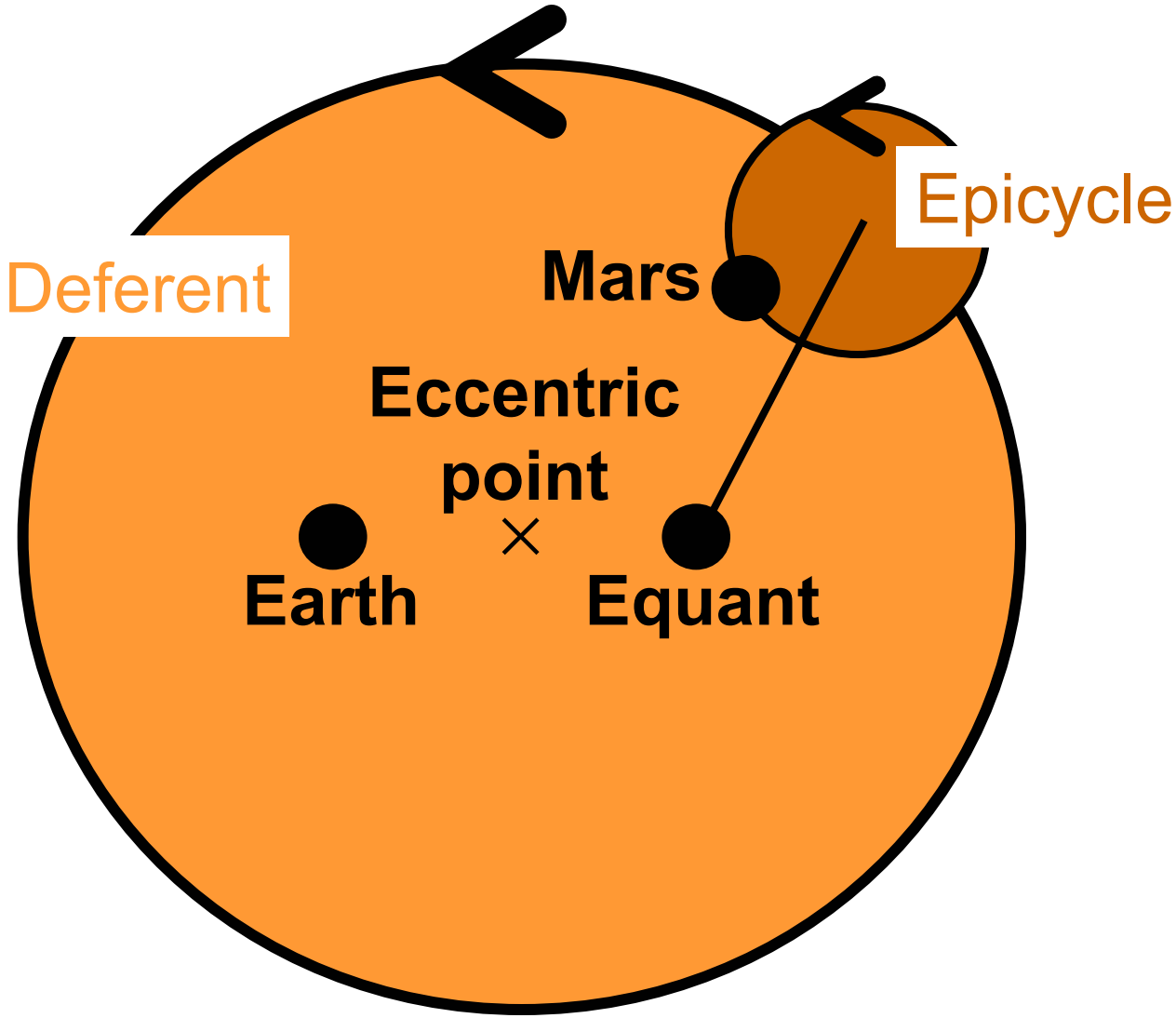


eccentricity = 0.09

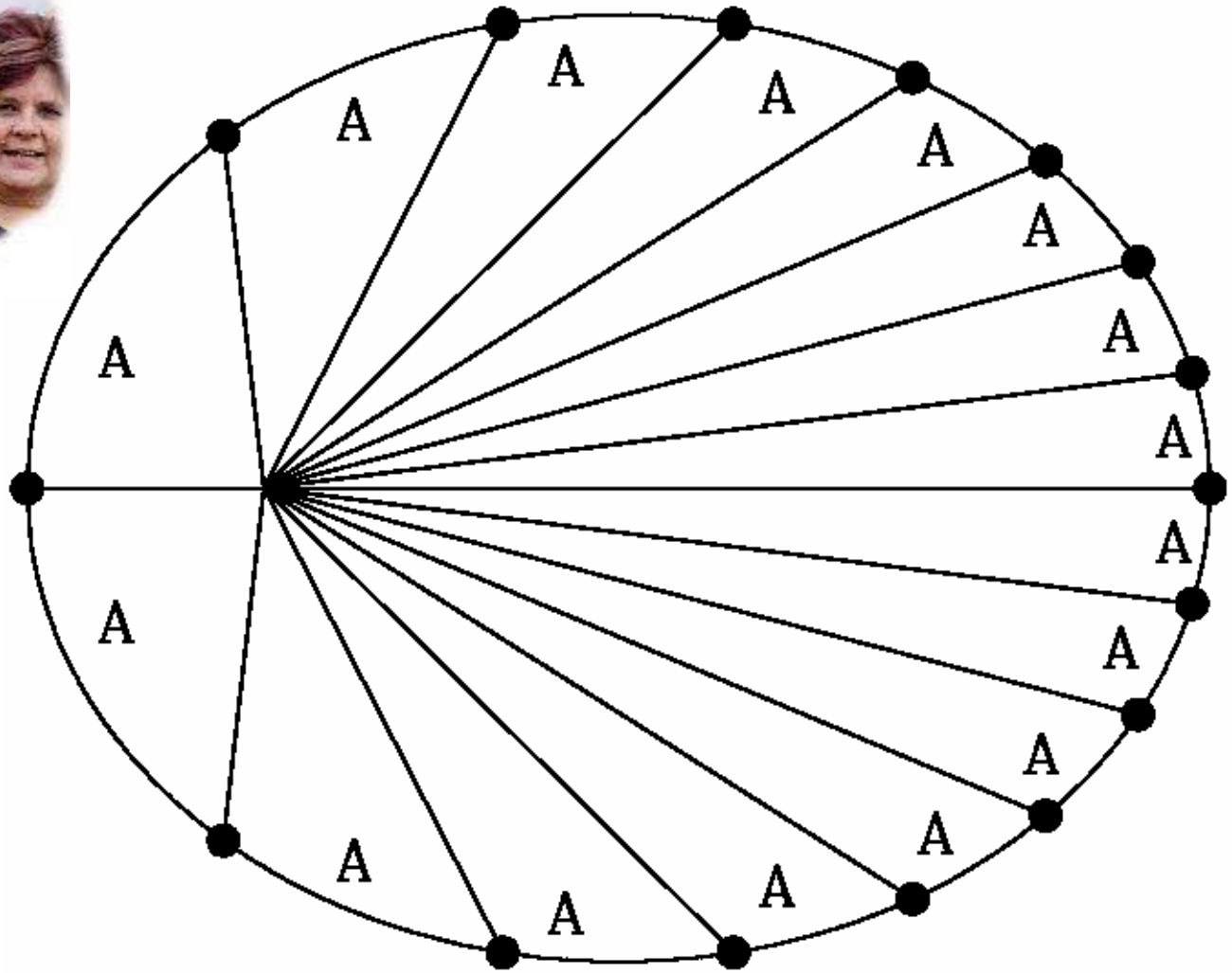


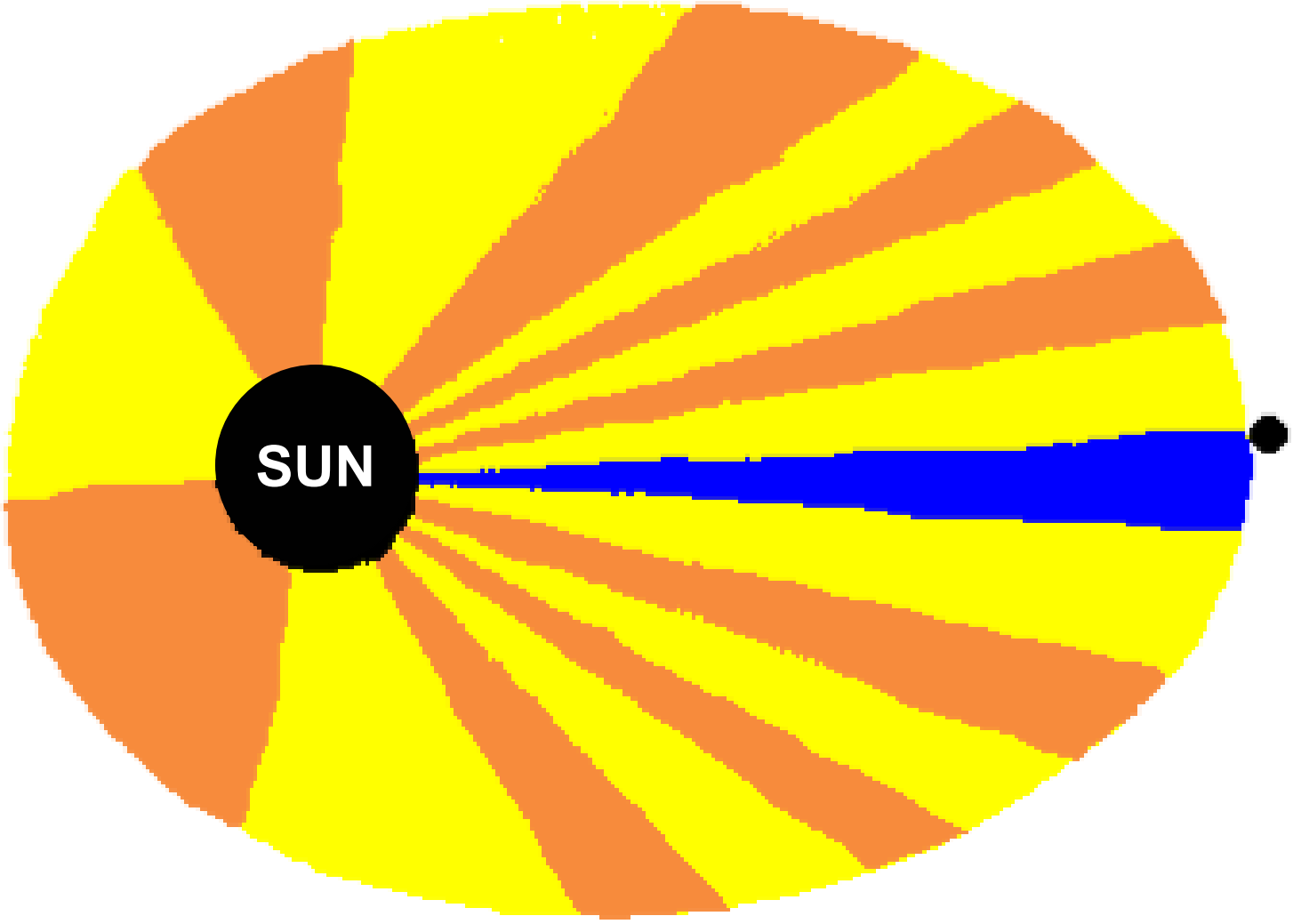
ellipse with eccentricity of Mars circle with same area

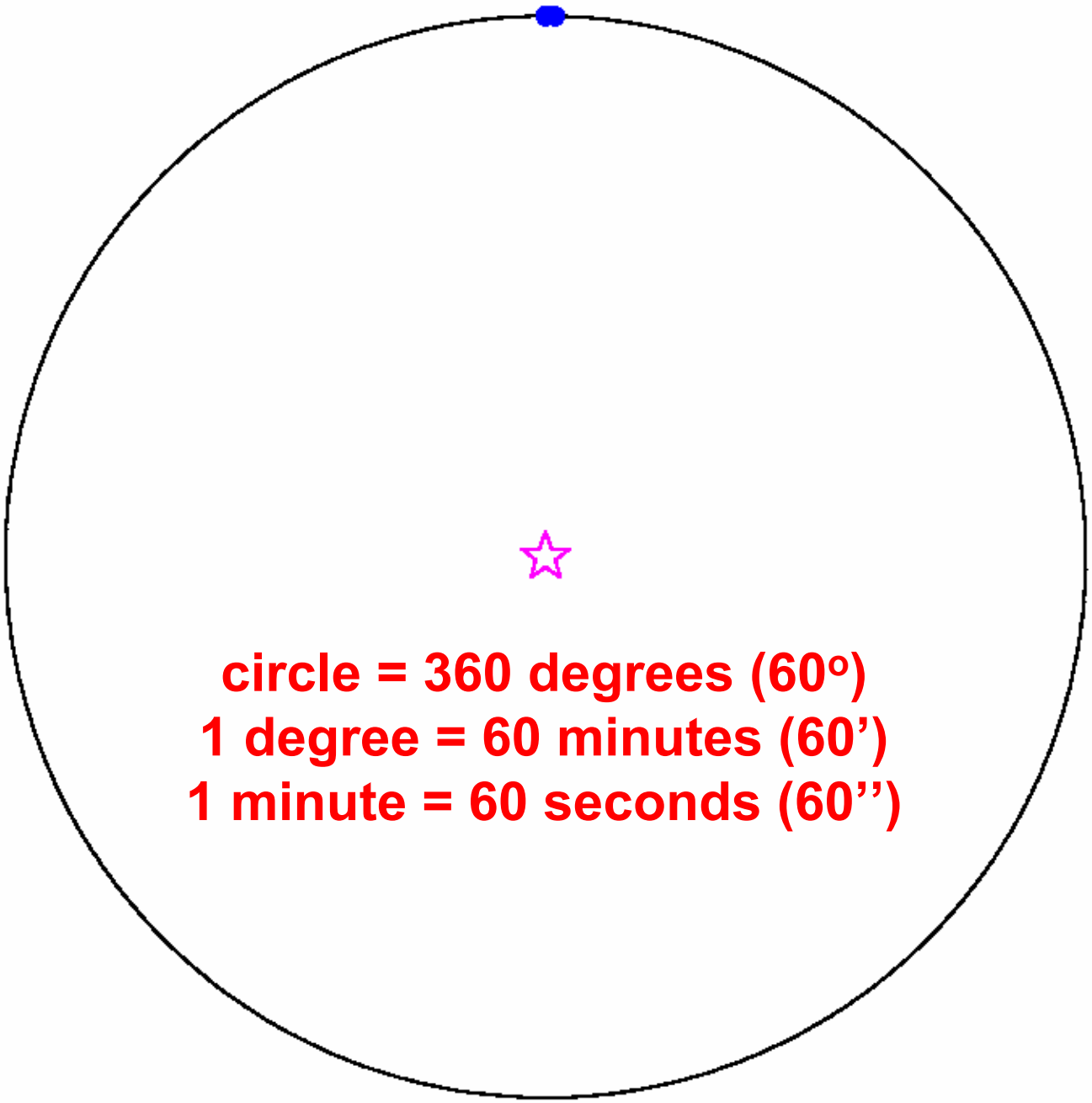
The Ptolemaic Epicycle

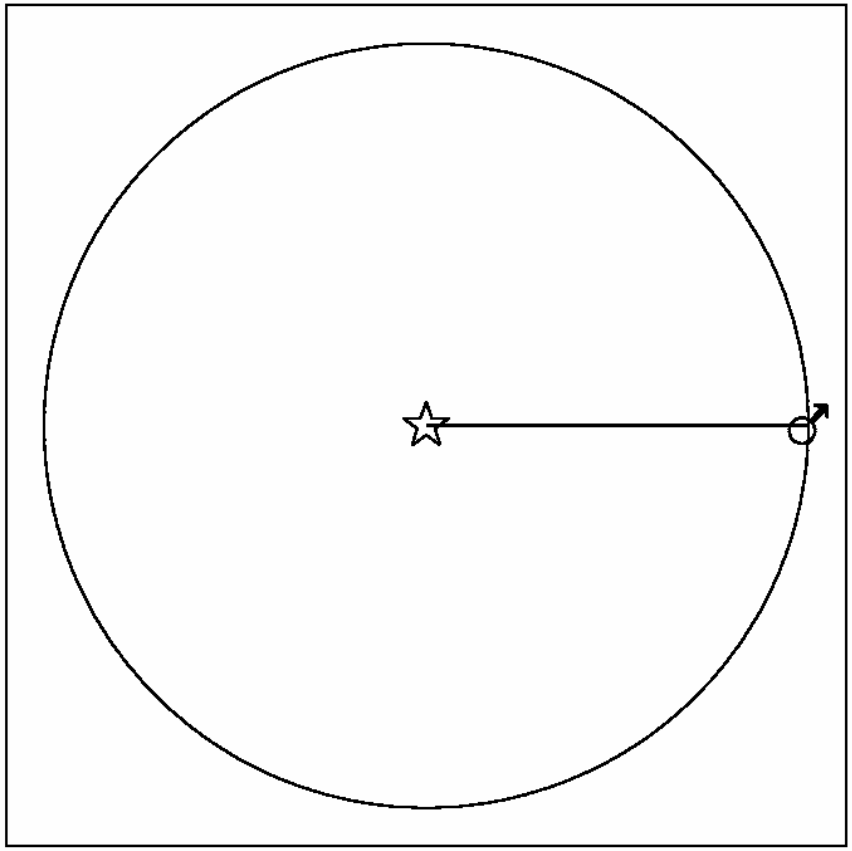


Kepler's 2nd Law

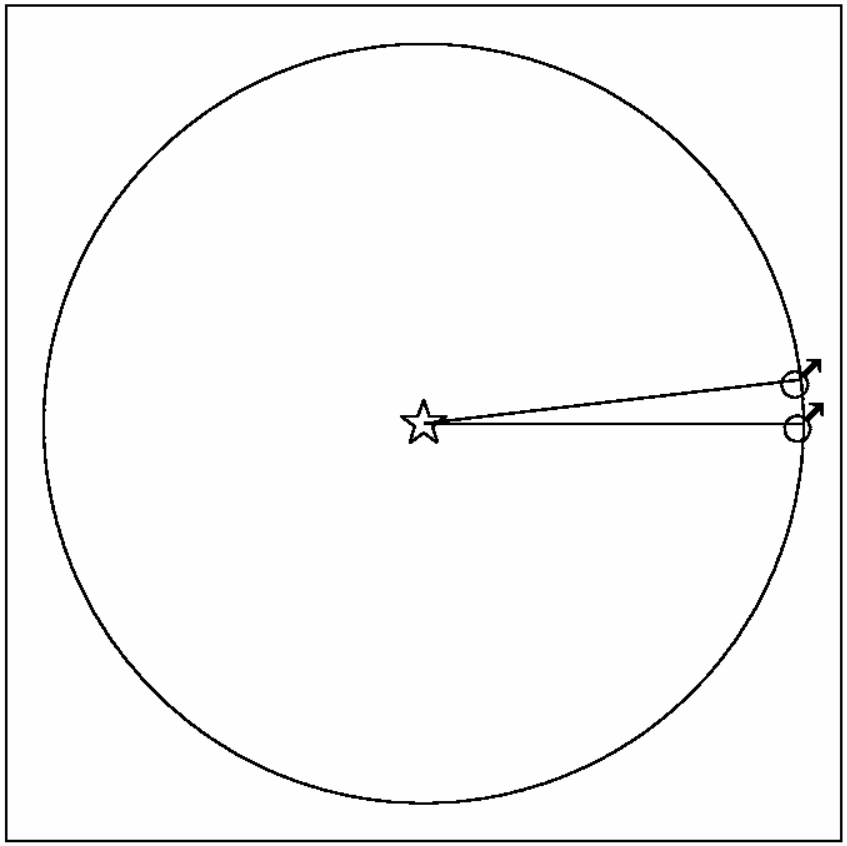



SUN


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

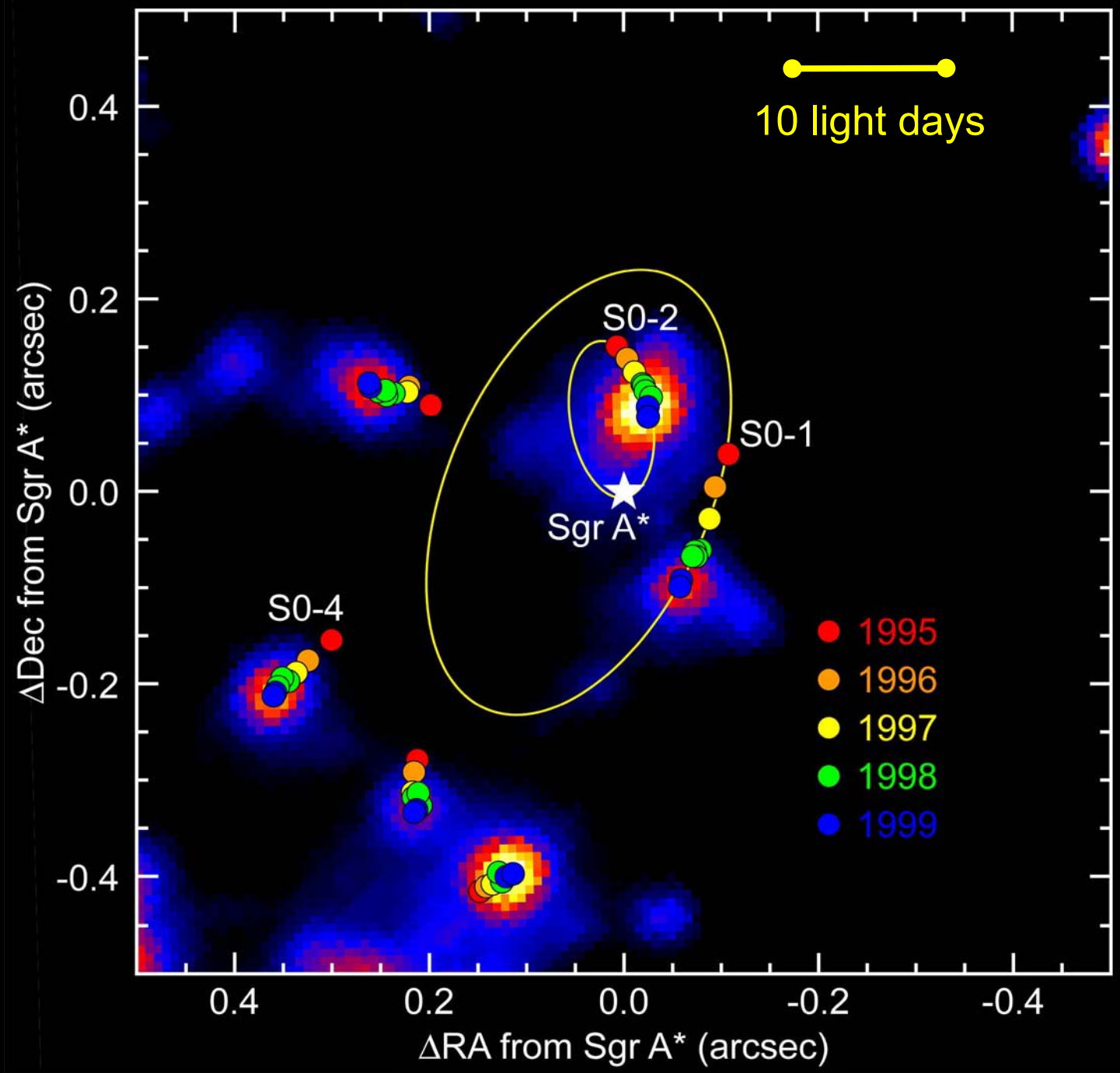


8 minutes of arc



50 X 8 minutes of arc

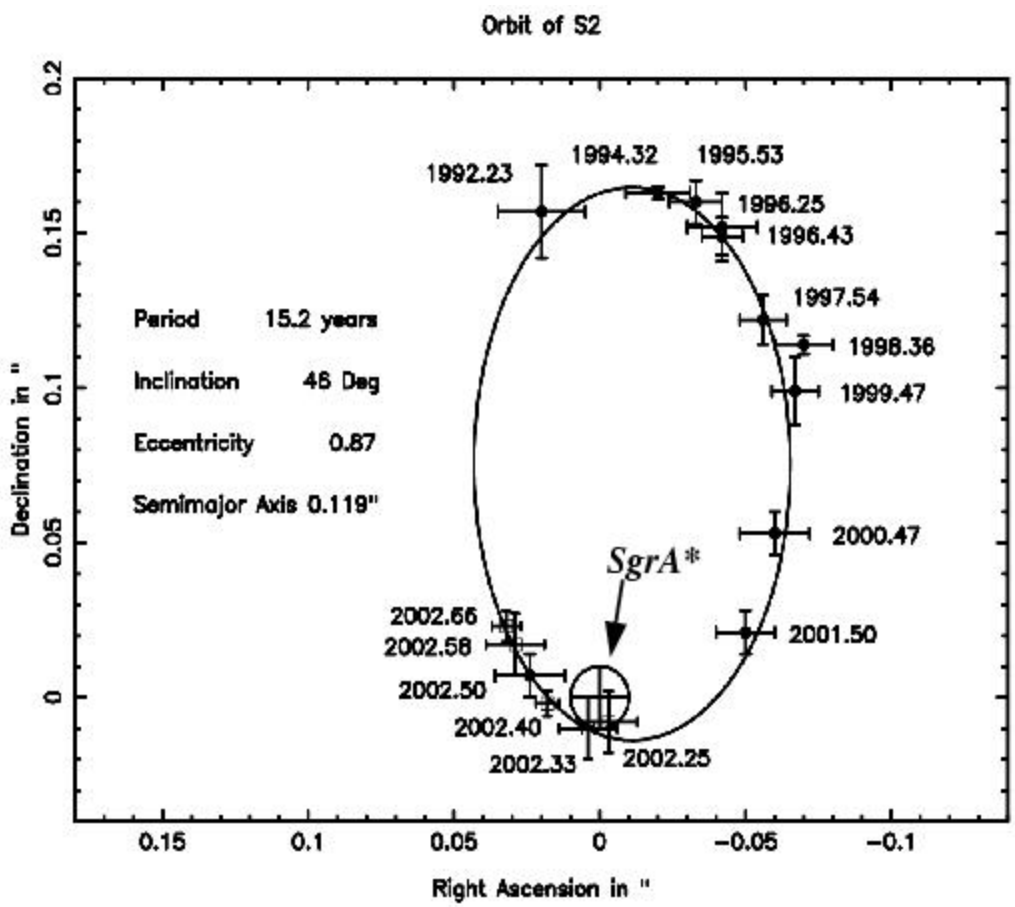
Ghez et al.


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)

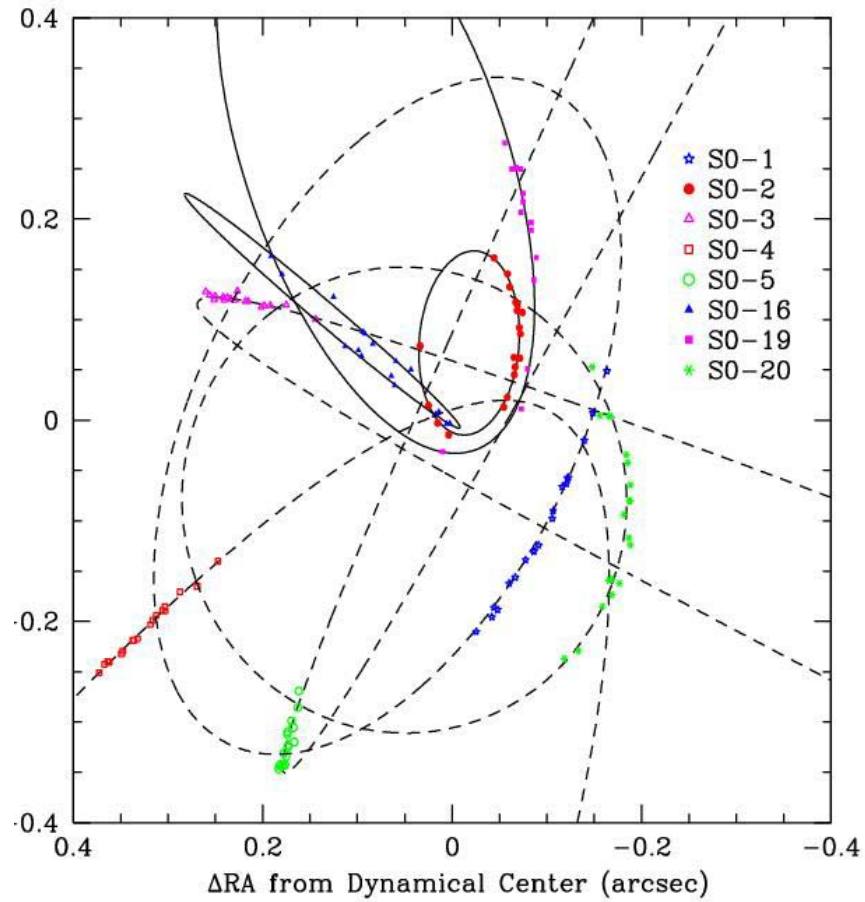
Orbits near the galactic center

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

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

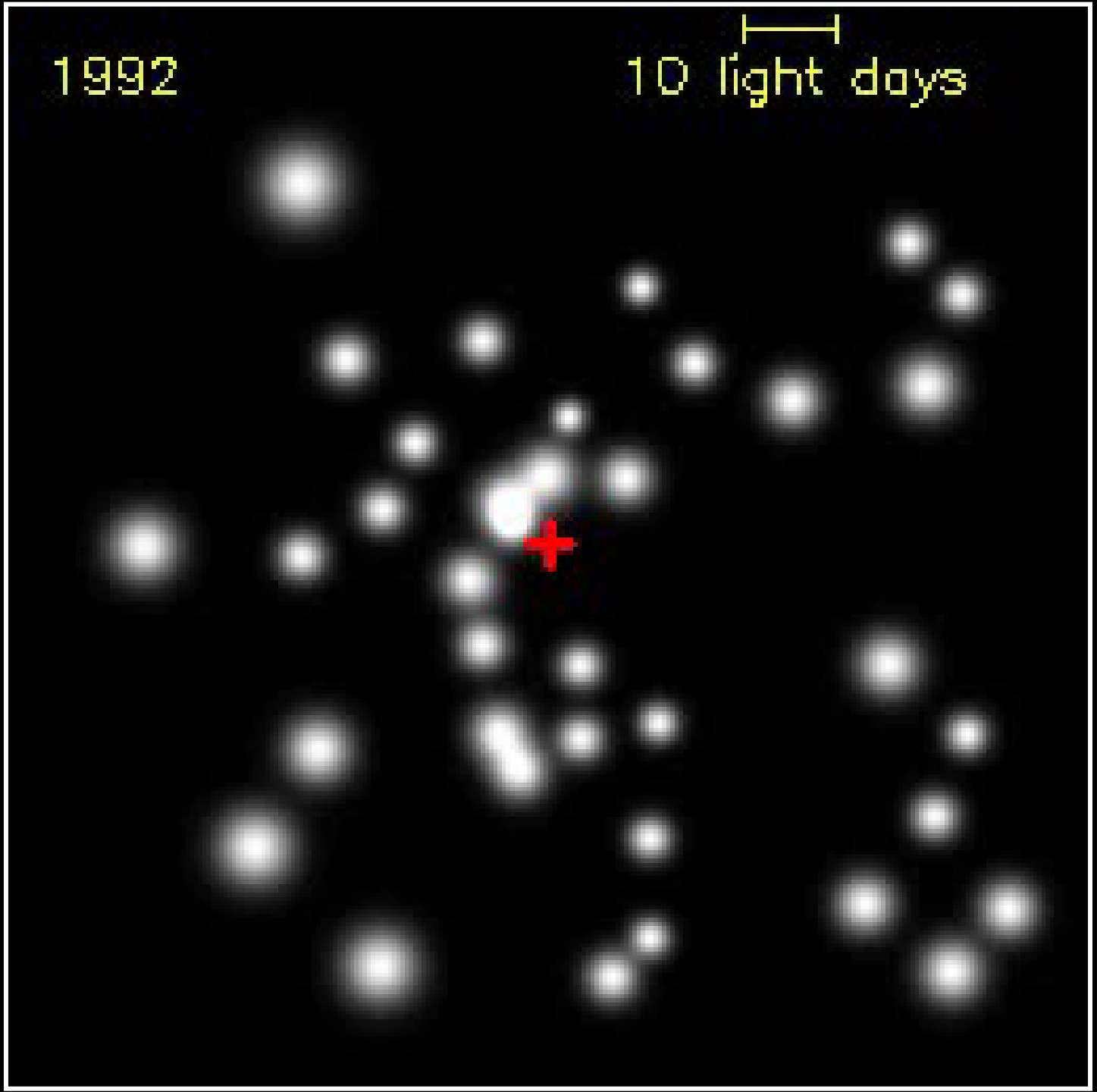


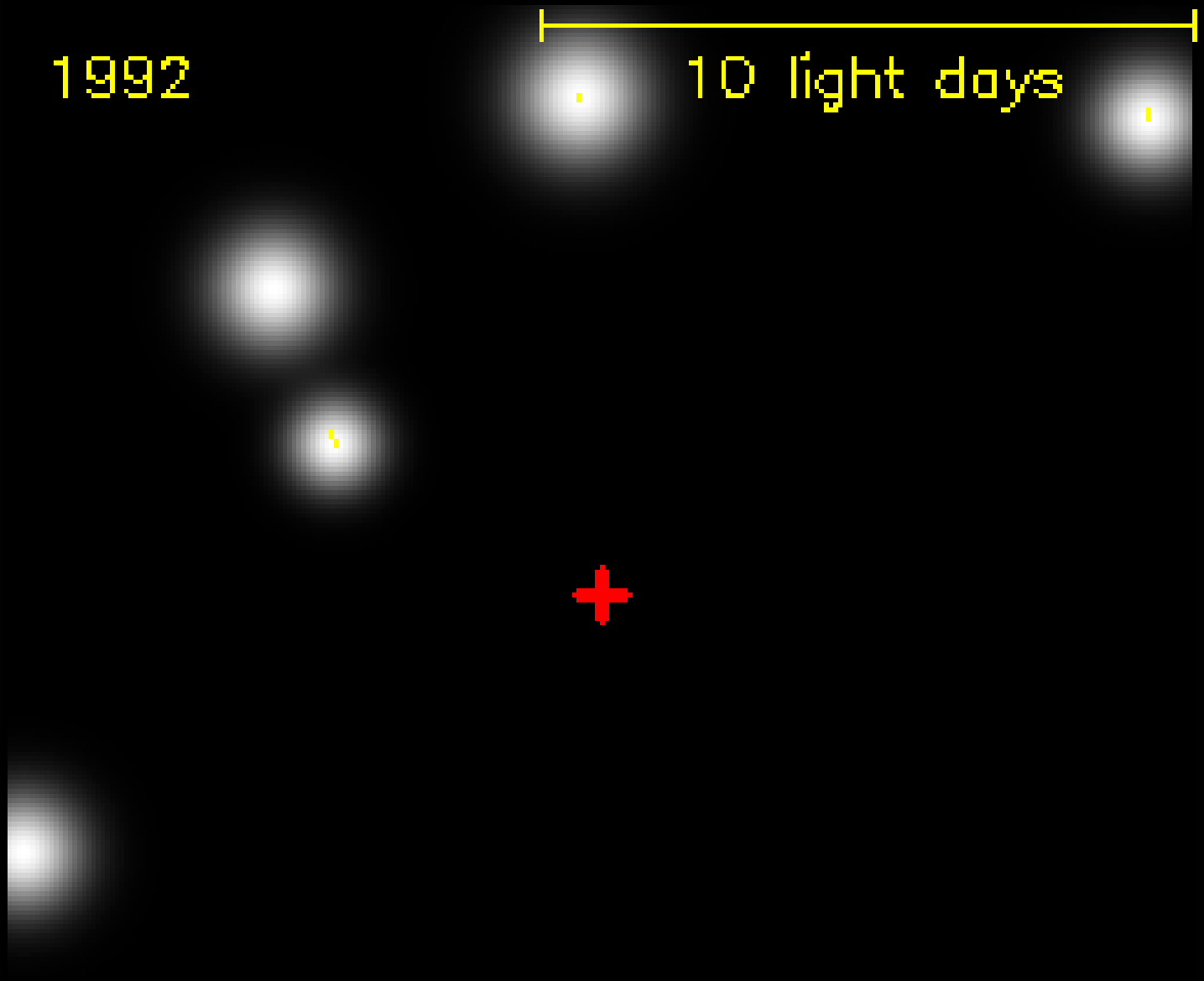
Schodel et al. (2002)



Ghez et al. (2003)

Schodel et al. 2002

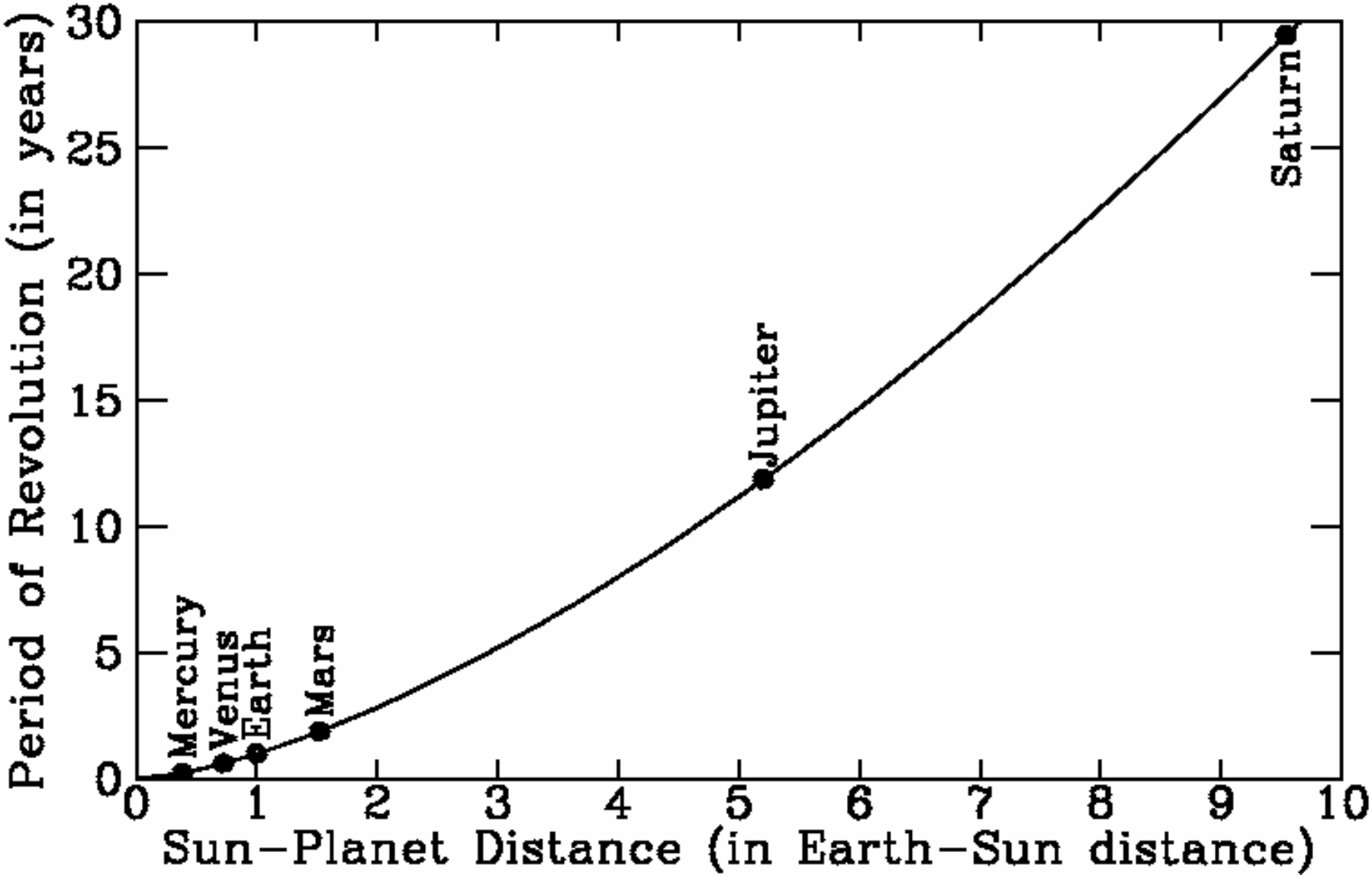


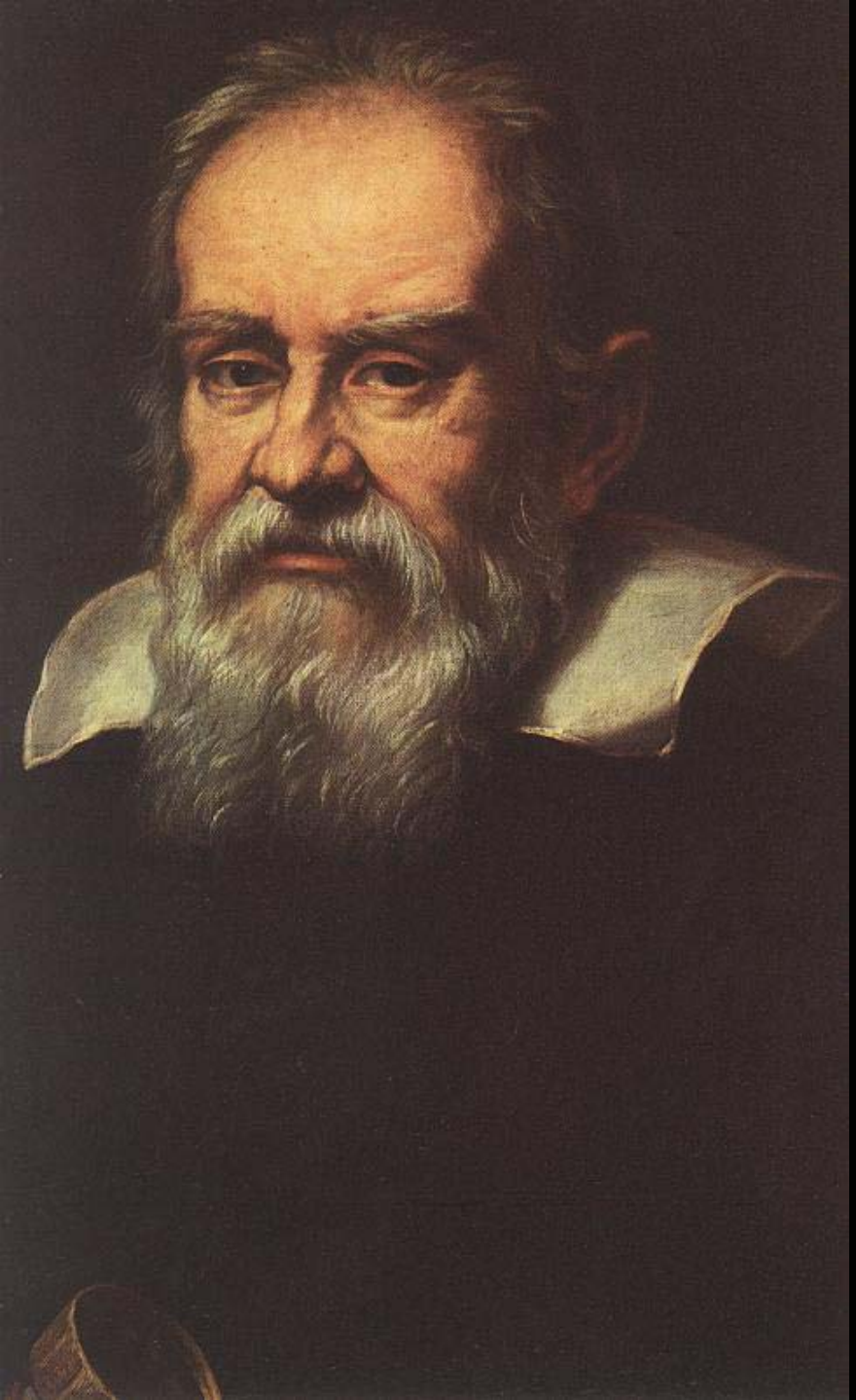


Schodel et al. 2002

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

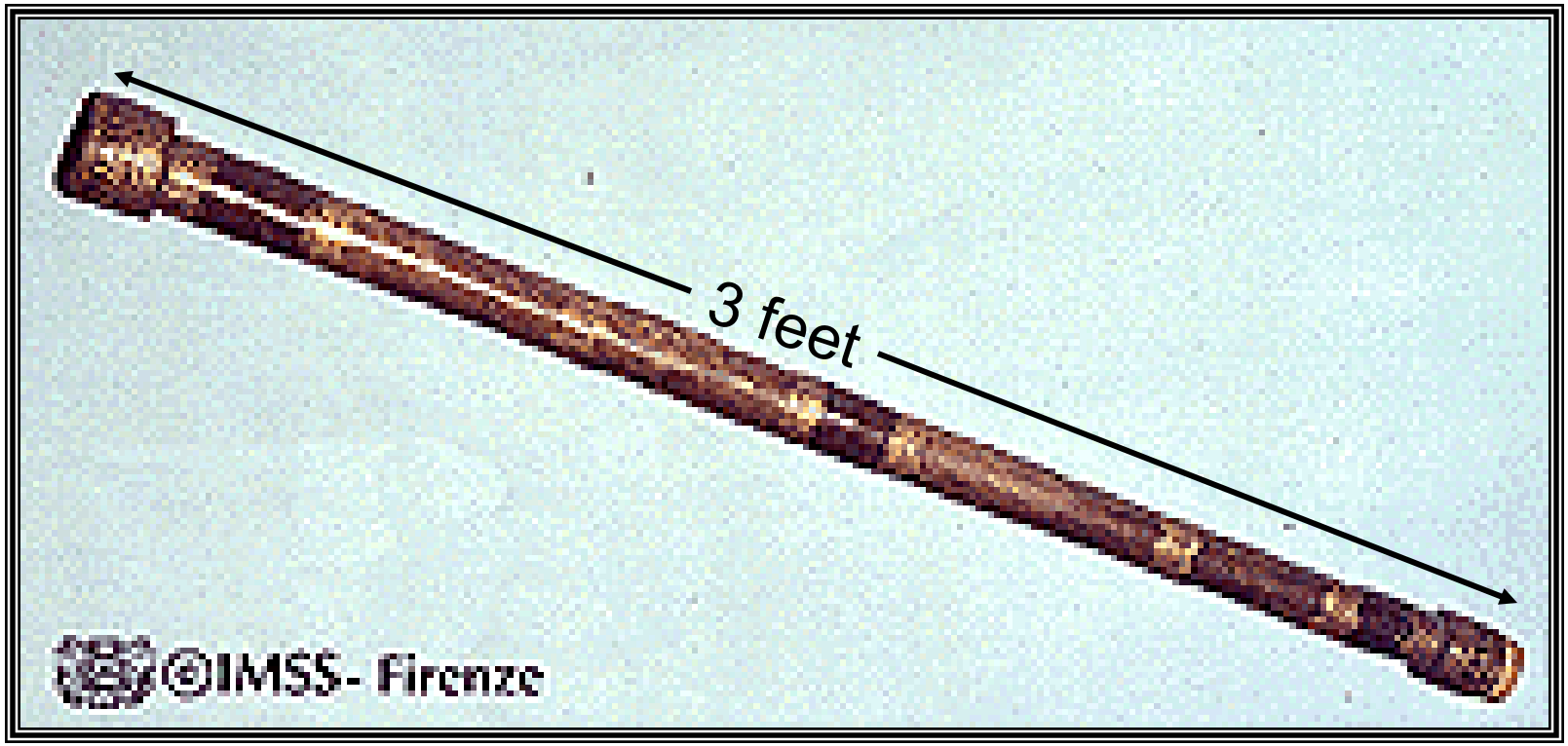
Ecce Homo
Caravaggio
1606
Palazzo Rosso,
Genoa

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

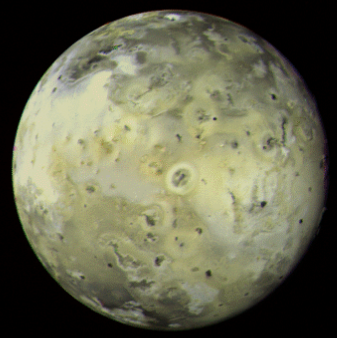
Wooden tube covered with red leather decorated in gold
21 X magnification
16mm objective lens

Museo di Storia della Scienza

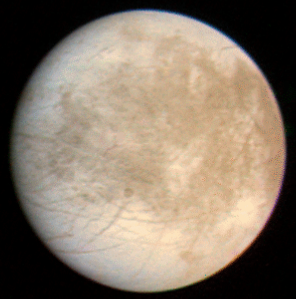
The Power of 3!

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

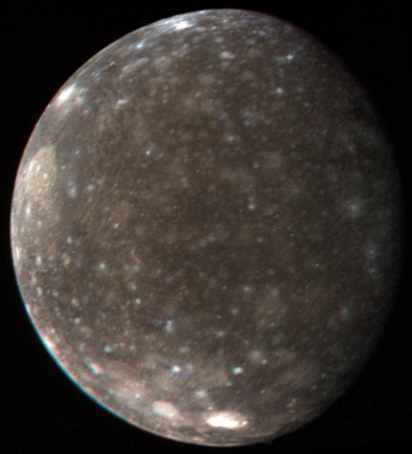


Io



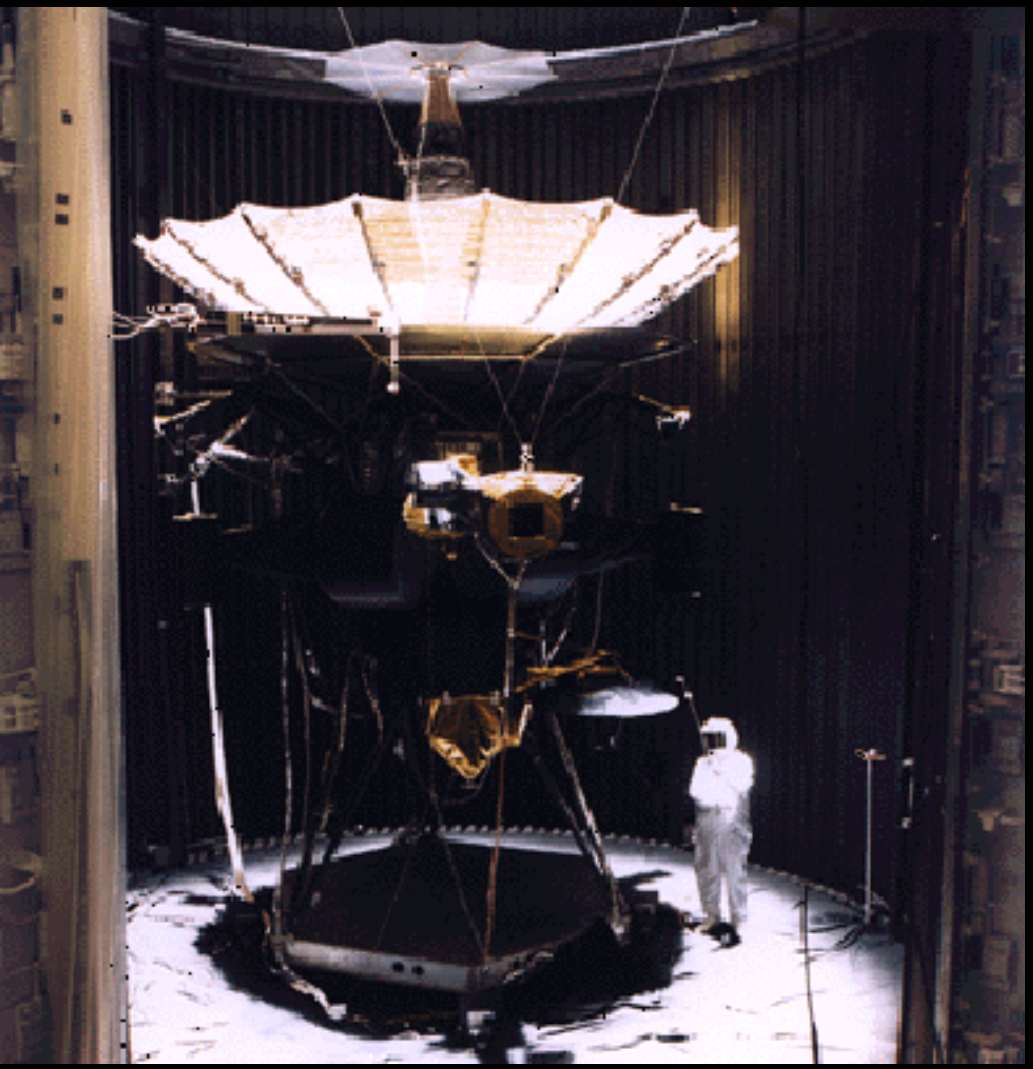
Europa

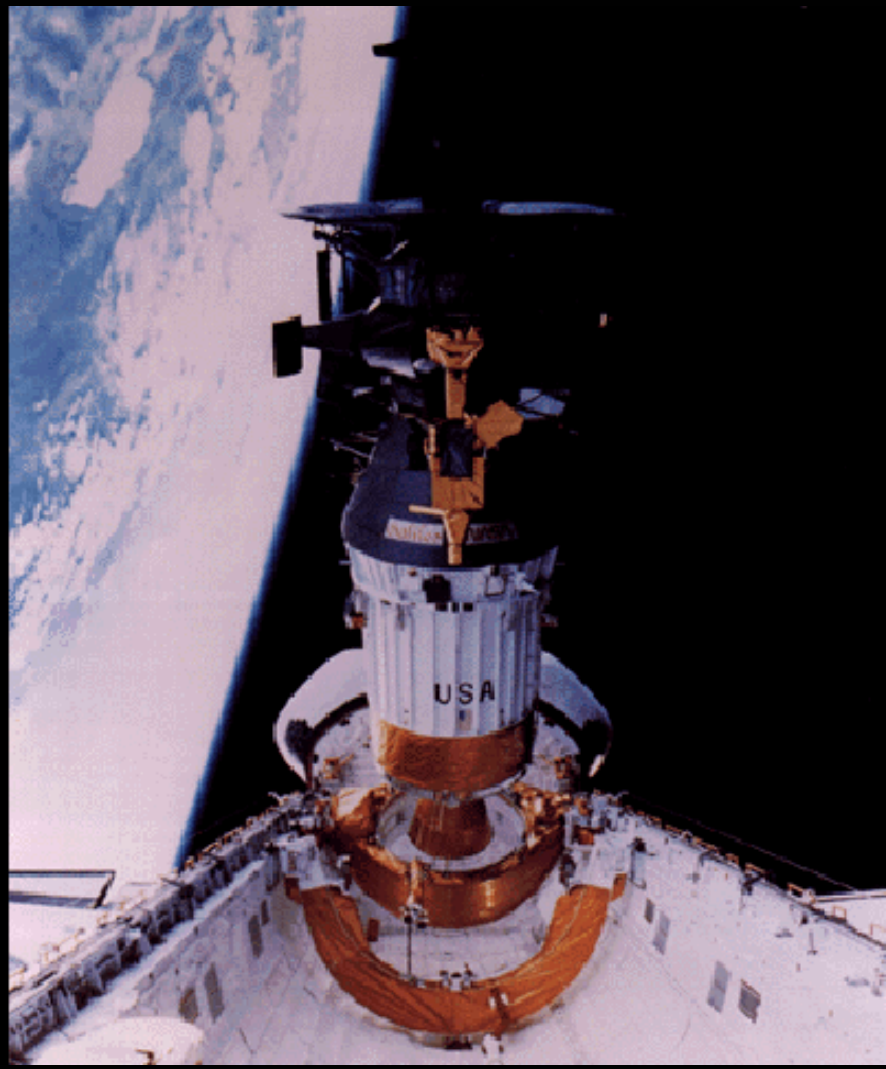
Ganymede



Callisto

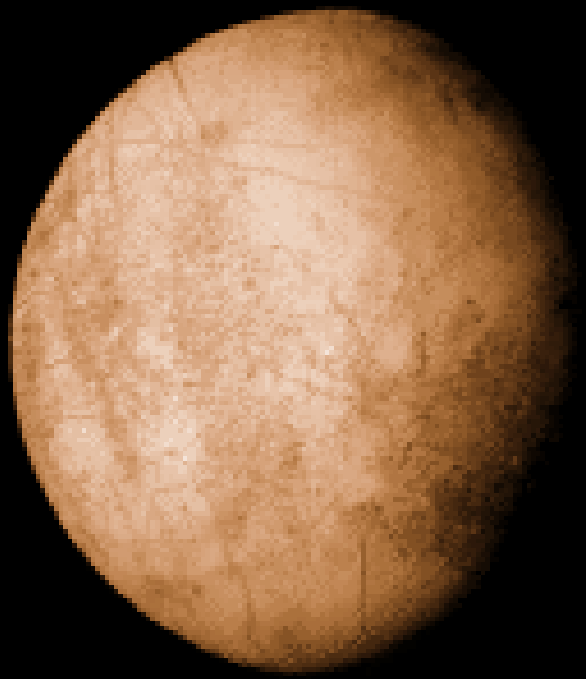
Galileo

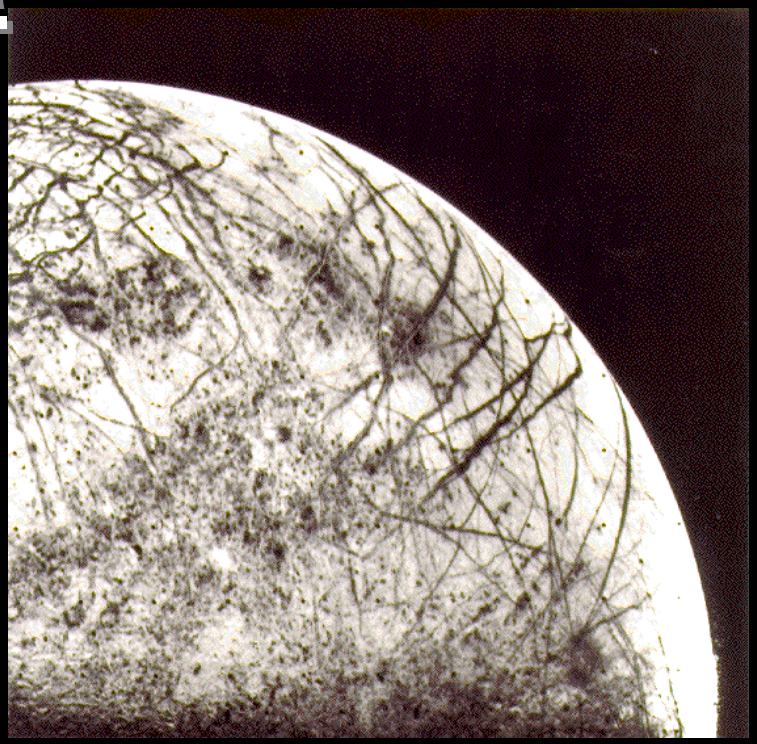


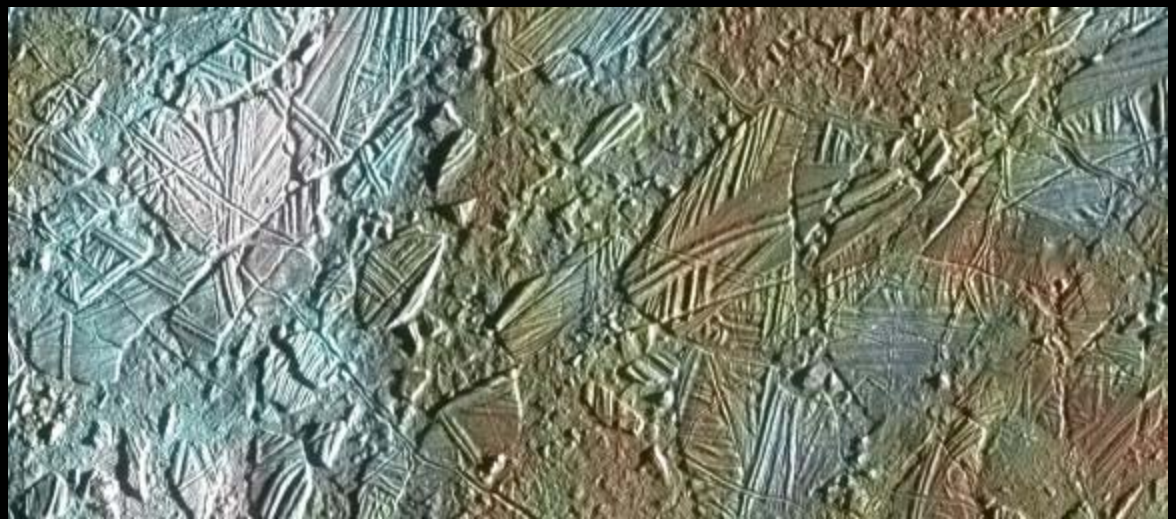


launched 1989 arrived at Jupiter 1995 plunged into Jupiter 2003

Europa

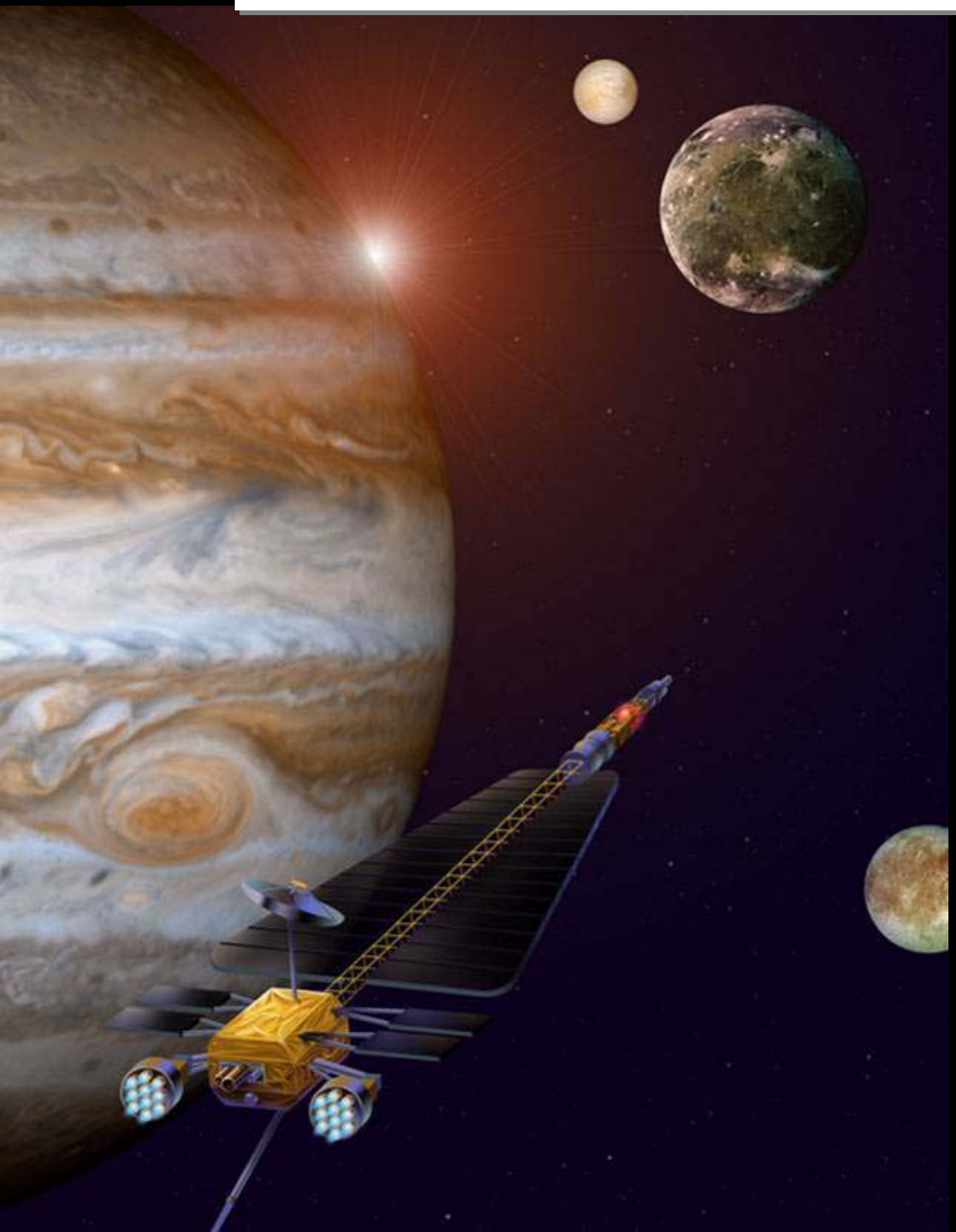


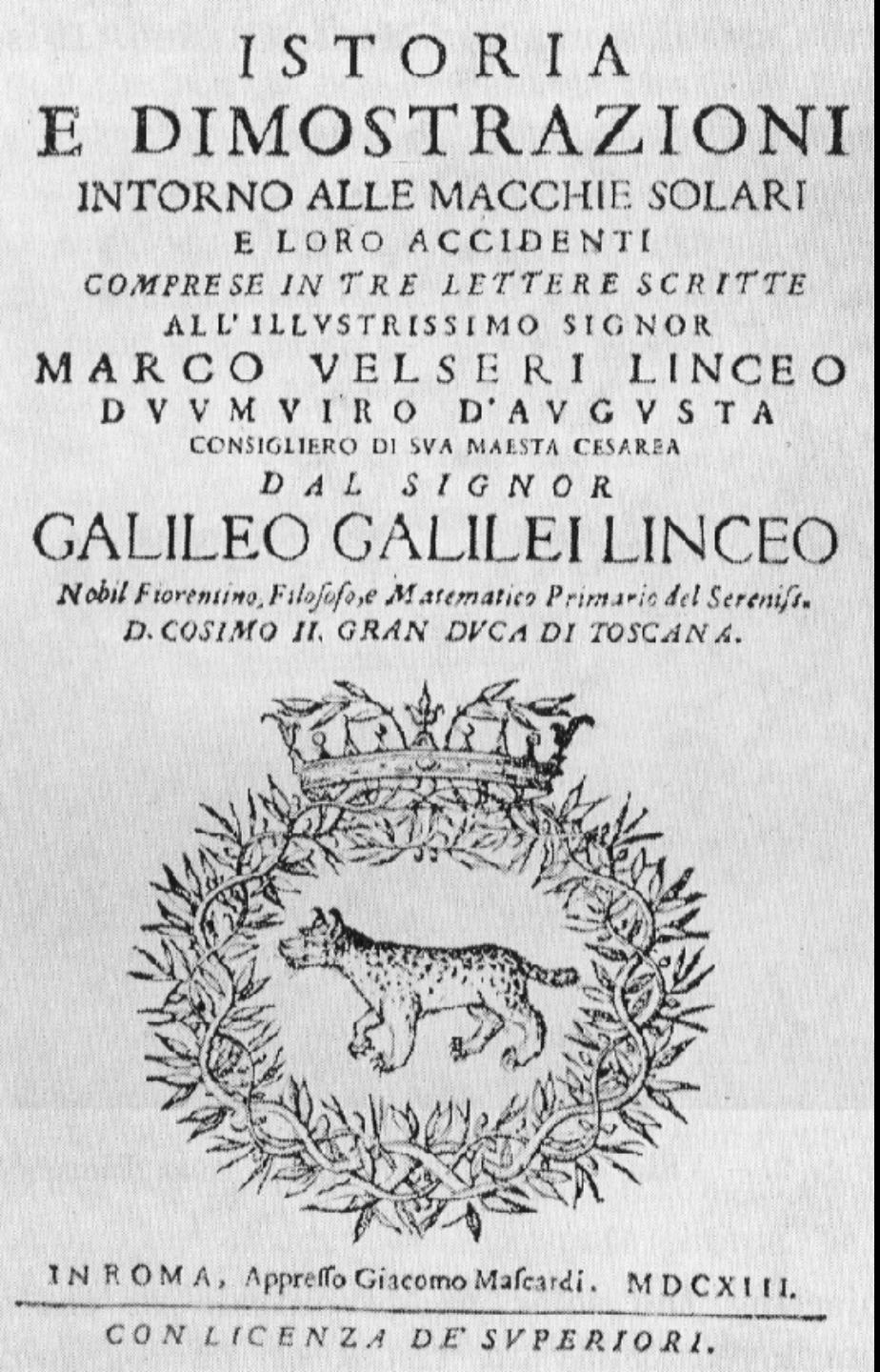




Giant tube worms at undersea hydrothermal vents

Jupiter Icy Moons Orbiter

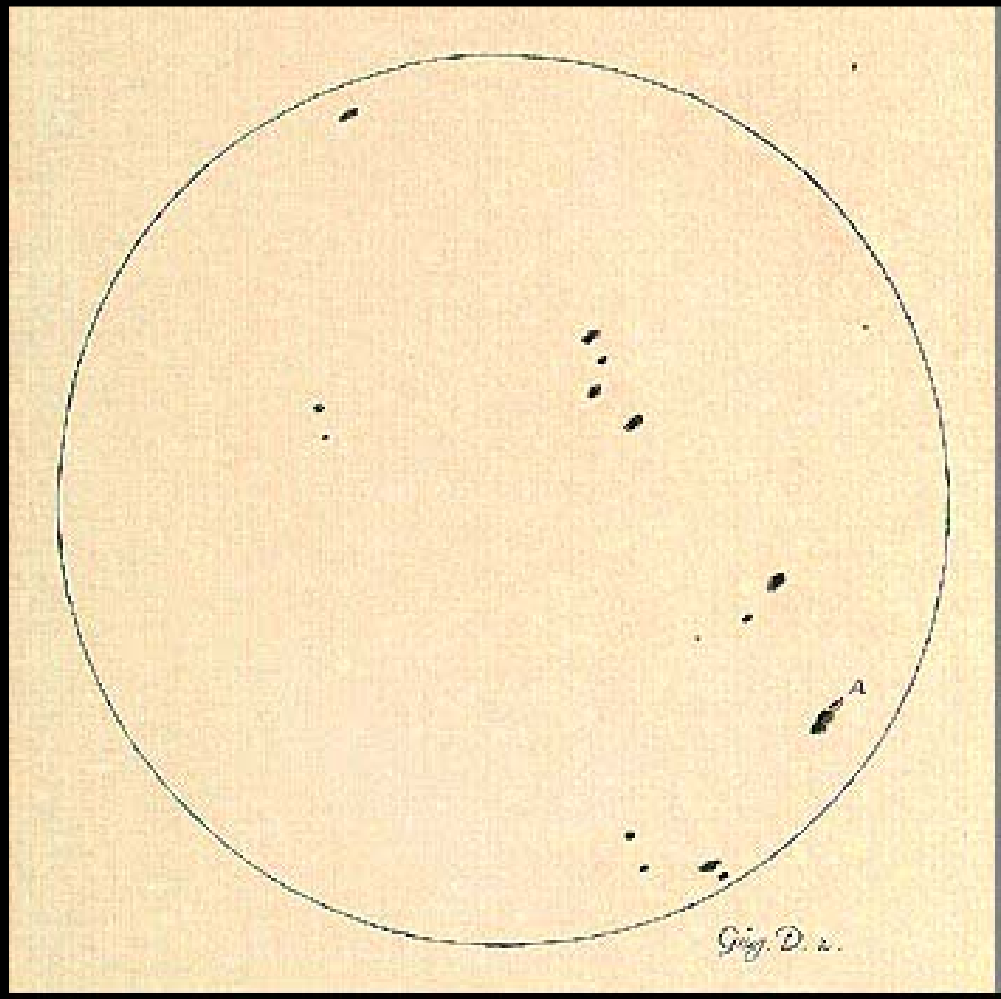




ISTORIA
E DIMOSTRAZIONI
INTORNO ALLE MACCHIE SOLARI
E LORO ACCIDENTI
COMPRESE IN TRE LETTERE SCRITTE
ALL'ILLVSTRISSIMO SIGNOR
MARCO VELSERI LINCEO
DVVMVIRO D'AVGVSTA
CONSIGLIERO DI SVA MAESTA CESAREA
DAL SIGNOR
GALILEO GALILEI LINCEO
Nobil Fiorentino, Filosofo, e Matematico Primario del Serenis.
D. COSIMO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

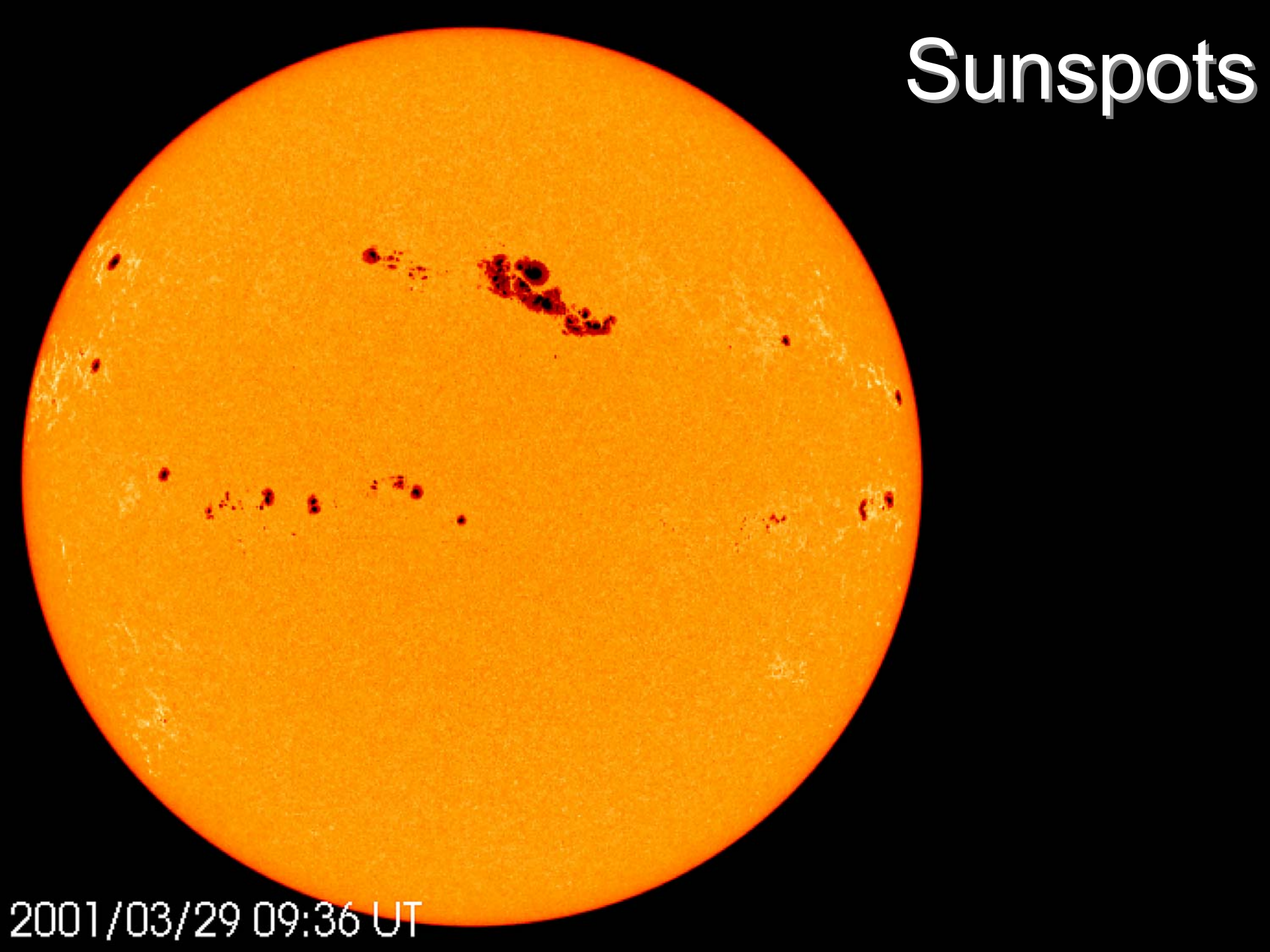
IN ROMA, Appresso Giacomo Mascardi. MDCXIII.

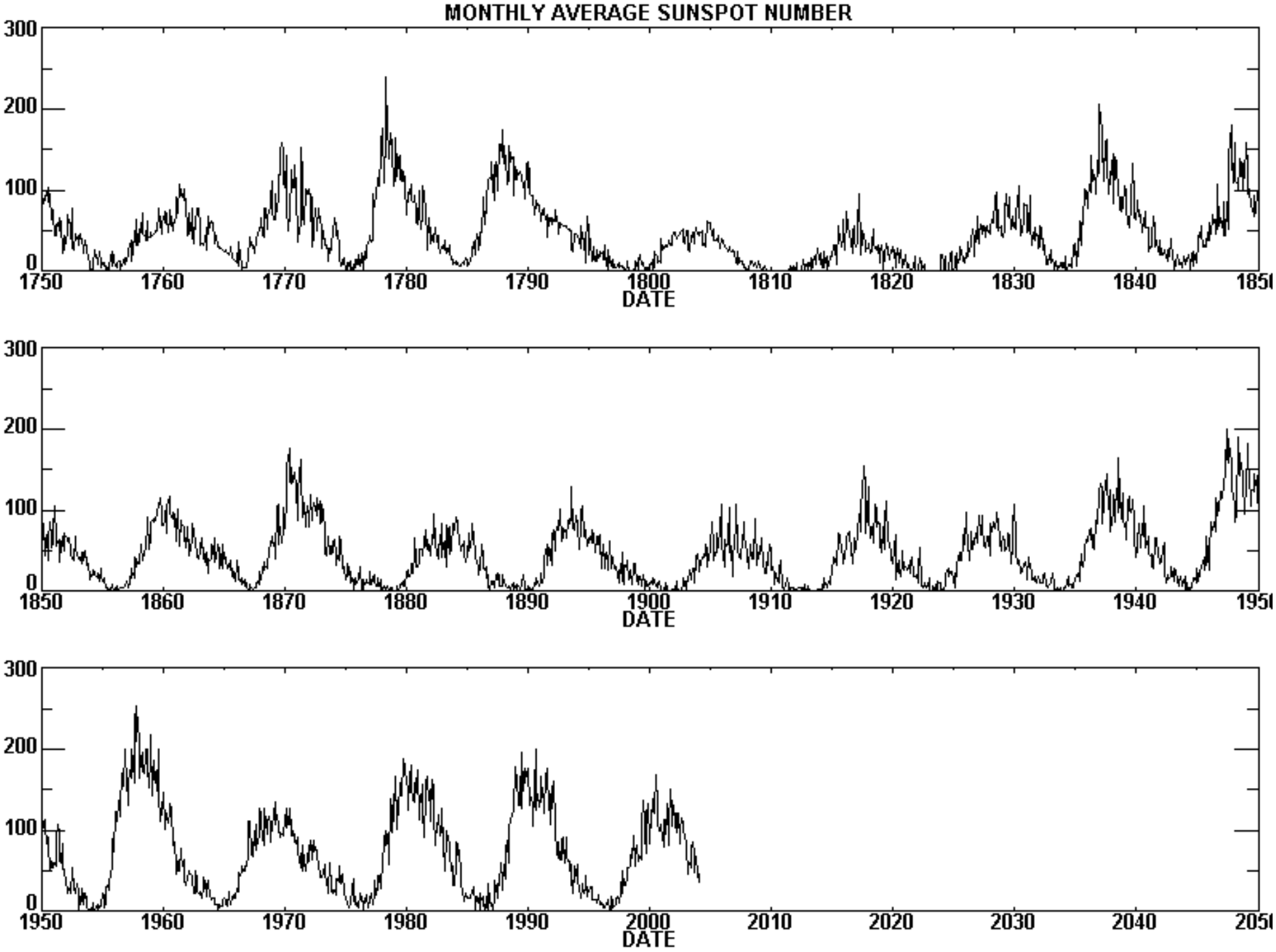
CON LICENZA DE' SVPERIORI.



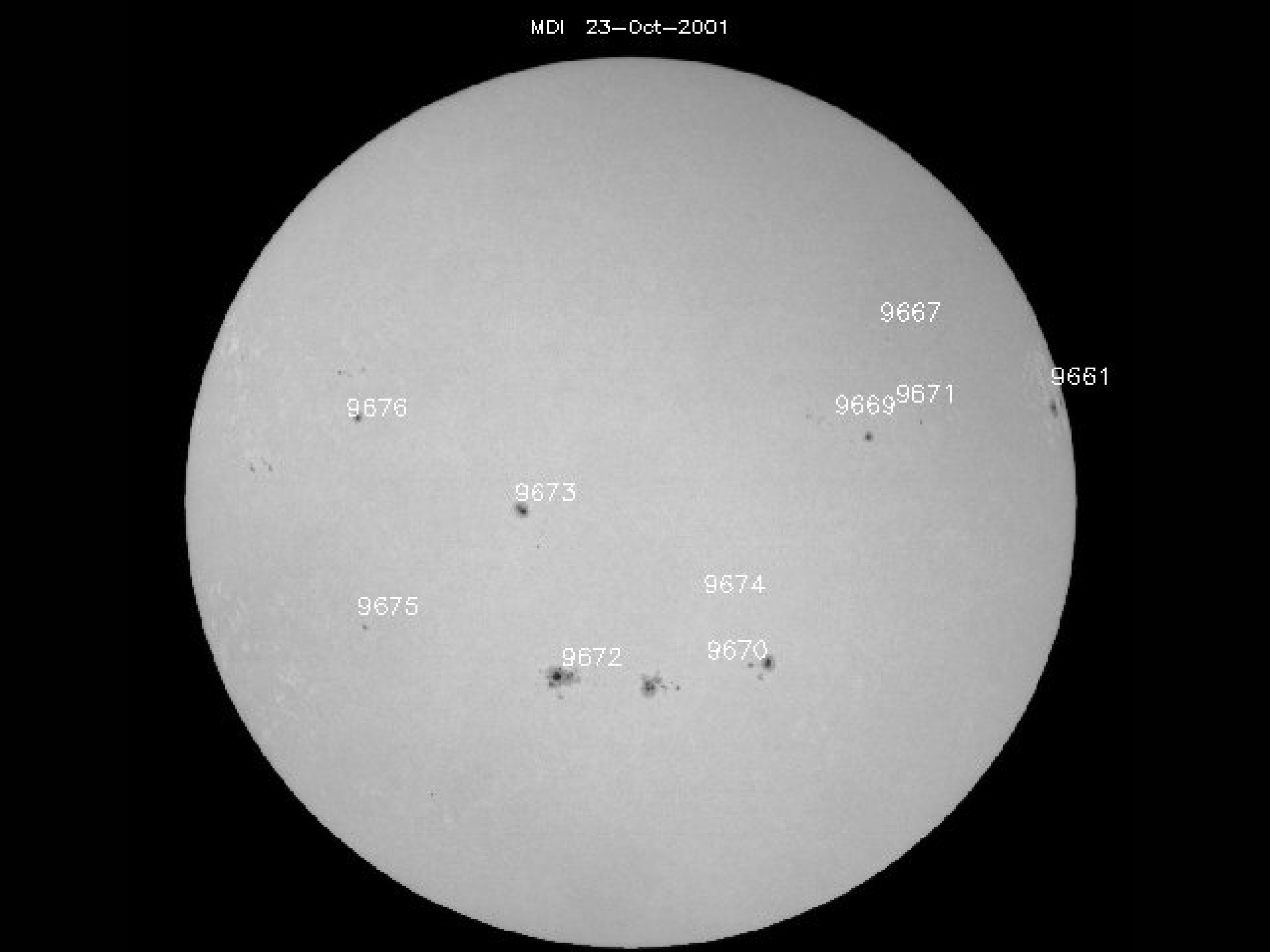
36 images in summer 1613

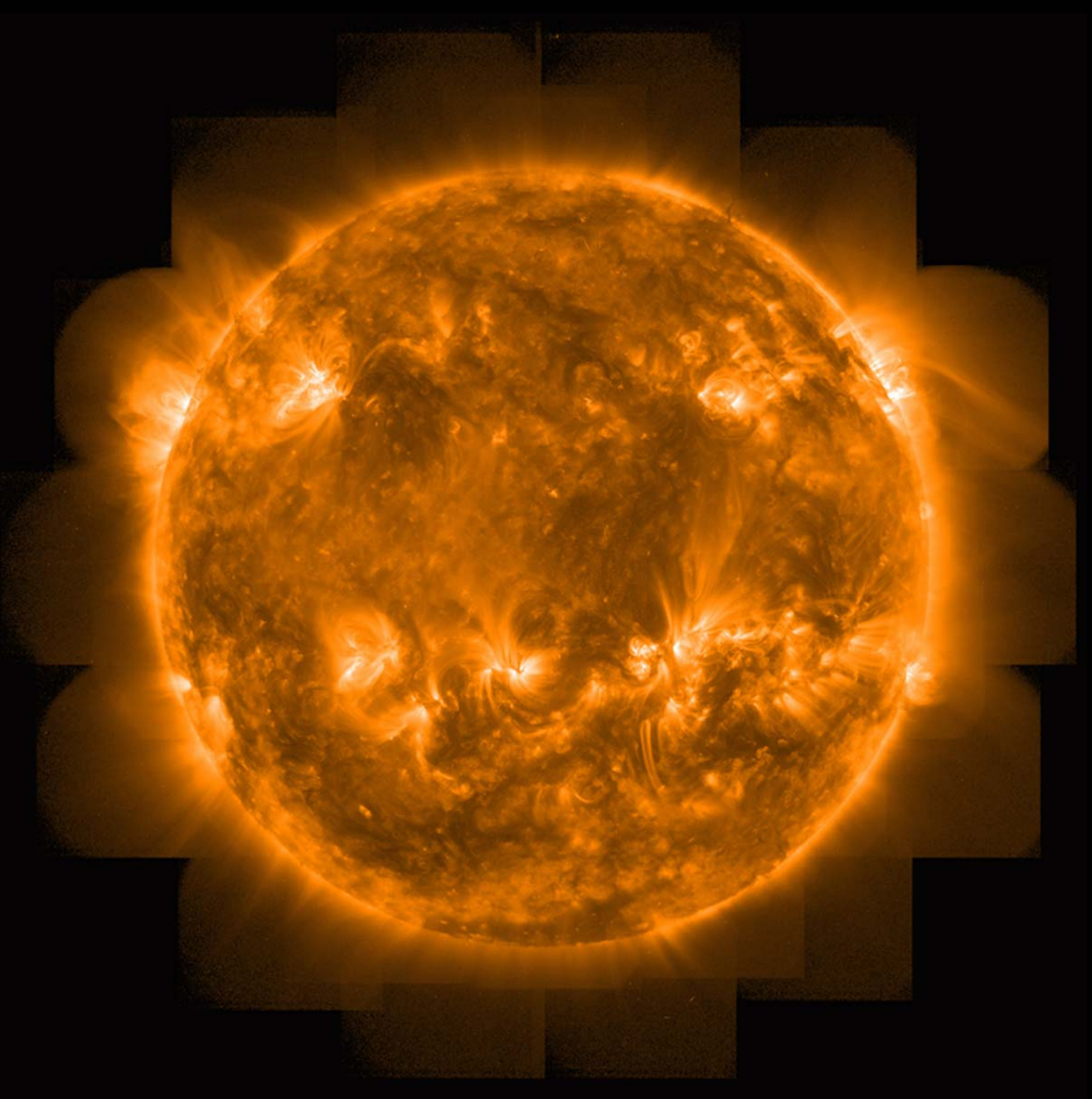
Sunspots




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

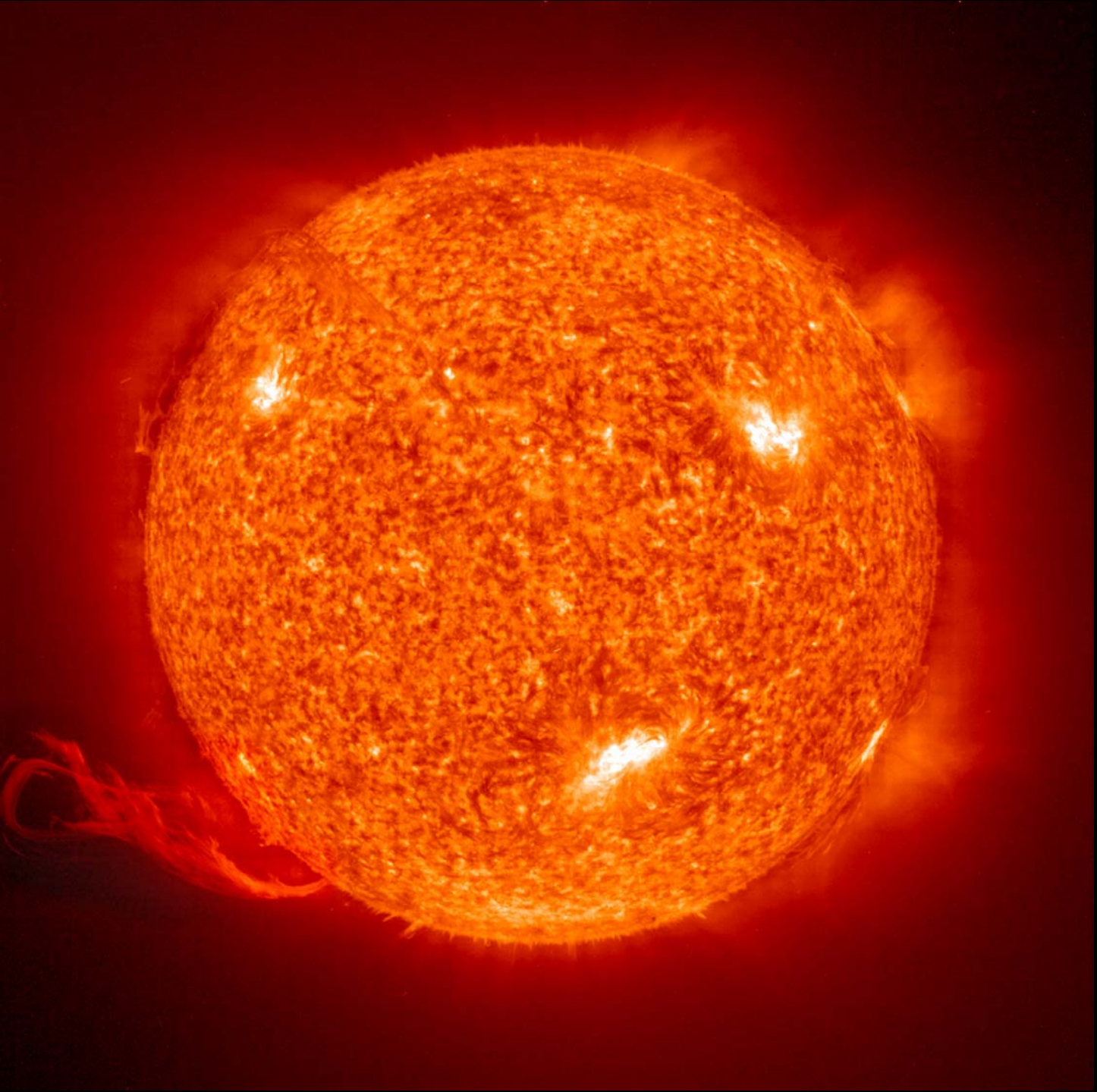
MDI 11-Apr-2005
0750
0749
0751


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

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.