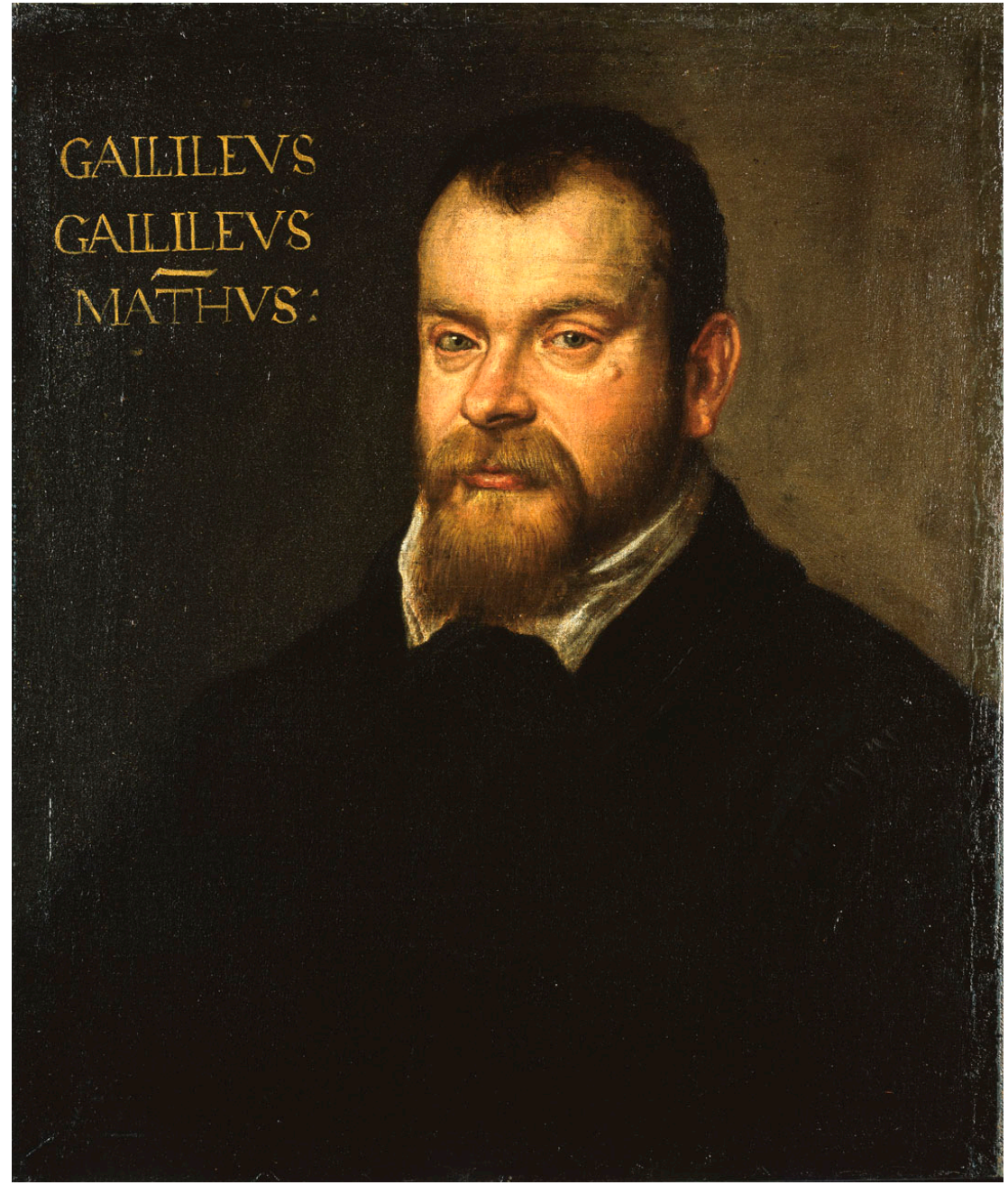
Life of Galileo

1564 – 1642 "Eppur si muove"

David Batagol


ALILEVS GAL: NOV OR
ORBIVM REPTO

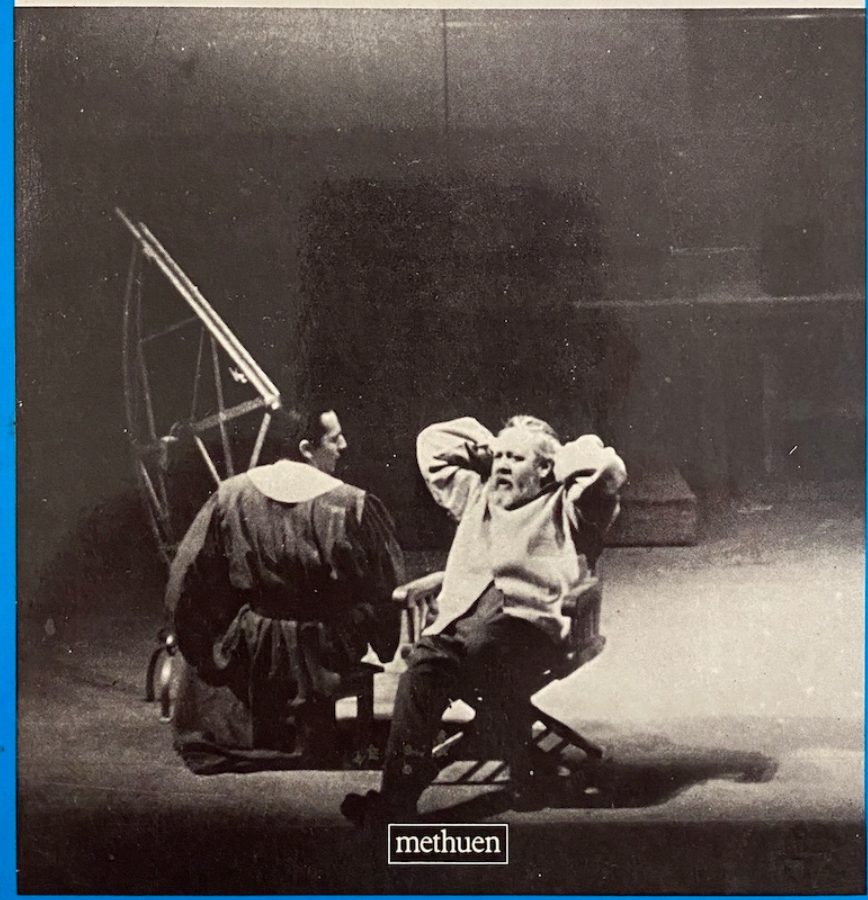

GAILILEVS
GAILILEVS
MATHVS:

Galileo and (possibly) young Galileo

Bertolt Brecht

Life of Galileo

Translated by John Willett
Edited by John Willett and Ralph Manheim



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Part 1- Young Galileo

- Born 15/02/1564 (three months after William Shakespeare) in Pisa
- Eldest of six
- Father, Vincenzo – Wool trader, also strong interest in Science, Philosophy and Music - multi-instrumentalist,
- Catholic Baptism at the age of four DAYS of age,
- As a child, he became skilled at building and making things with his hands, constructing models, pulling apart machinery and reassembling it to see how it worked etc.,
- Moved to Florence in 1574 at age 10

Young Galileo(cont'd)

- Vincenzo - very active in the local music scene, local performances, lots of musical vistors
- Galileo began to learn several instruments via his father. Lute was his favourite
- Also learnt the arts, painting, drawing etc
- Debate and intellectual discussion a favourite pastime
- Taught by his father and tutors to the Aristotlean method of independent study, observation and experimentation.
- Grew up in an intellectually stimulating household
- This was around the peak of the Renaissance - much inspiration.

More Young Galileo

- At age 15, sent to study at the Benedictine Monastery of Santa Maria Di Vallambrosa
- Further education in religious studies, but also logic and introduction to Aristotlean method.
- Did briefly consider becoming a Monk
- Had to leave after several months, some dispute as to why, some sources state medical illness, others that his father recalled him, as he could not afford to keep him there.
- Also considered pursuing a career as an artist

Vincenzo Galilee

Vincenzio Galilee

- From an ancient Florentine family that had once been wealthy and powerful, but by Vincenzio's time, the money and power had all gone.

- Wrote several books, including one called “The dialogue of ancient and modern music’’, very active in the Florentine Music community and had frequent visits from other musicians.

- Was involved in the Florentine Camerata, a group of musicians who experimented with and developed the beginnings of opera.

- Was considered a local authority in the Musical world. Was invited to spend time with Duke Albrecht (Albert V) of Bavaria in Munich during his time in Florence.

Duke Albrecht of Bavaria

The Duke and Duchess enjoying a chess evening

Benedictine Monastery of Santa Maria Di Vallambrosa

University of Pisa- Galileo starts his Medical Degree

Pisa University-1581

- Galileo passed the Bachelor's exam at age 16 or 17, allowing him entry the University of Pisa.
- Chose (or probably pushed by his father) into choosing to study Medicine. A Master's Degree had to be completed to graduate Medicine.
- Several months into his degree studies, he stumbled into a lecture on Geometry, given by Ostillio Ricci, a friend of Vincenzo Galilee
- He became very interested in Geometry, and was offered the opportunity to take Ricci's course as well.
- He also ended up having personal tutorials with Ricci.
- Eventually, there was a 'showdown' between Vincenzio and his son, but in the end, Vincenzo agreed to support Galileo in pursuing Geometry and Mathematics.

Ostilio Ricci, Mathematician

Pisa University (Cont'd)

- Nicknamed 'the Wrangler' by fellow students – Frustrated both lecturers and fellow student by questioning everything.

- He even started to question the wisdom of Aristotle himself - remember this for later.

- Unfortunately, in 1585 (aged 21), he had to leave the University without graduating - his father could no longer afford the University fees.

After the University of Pisa

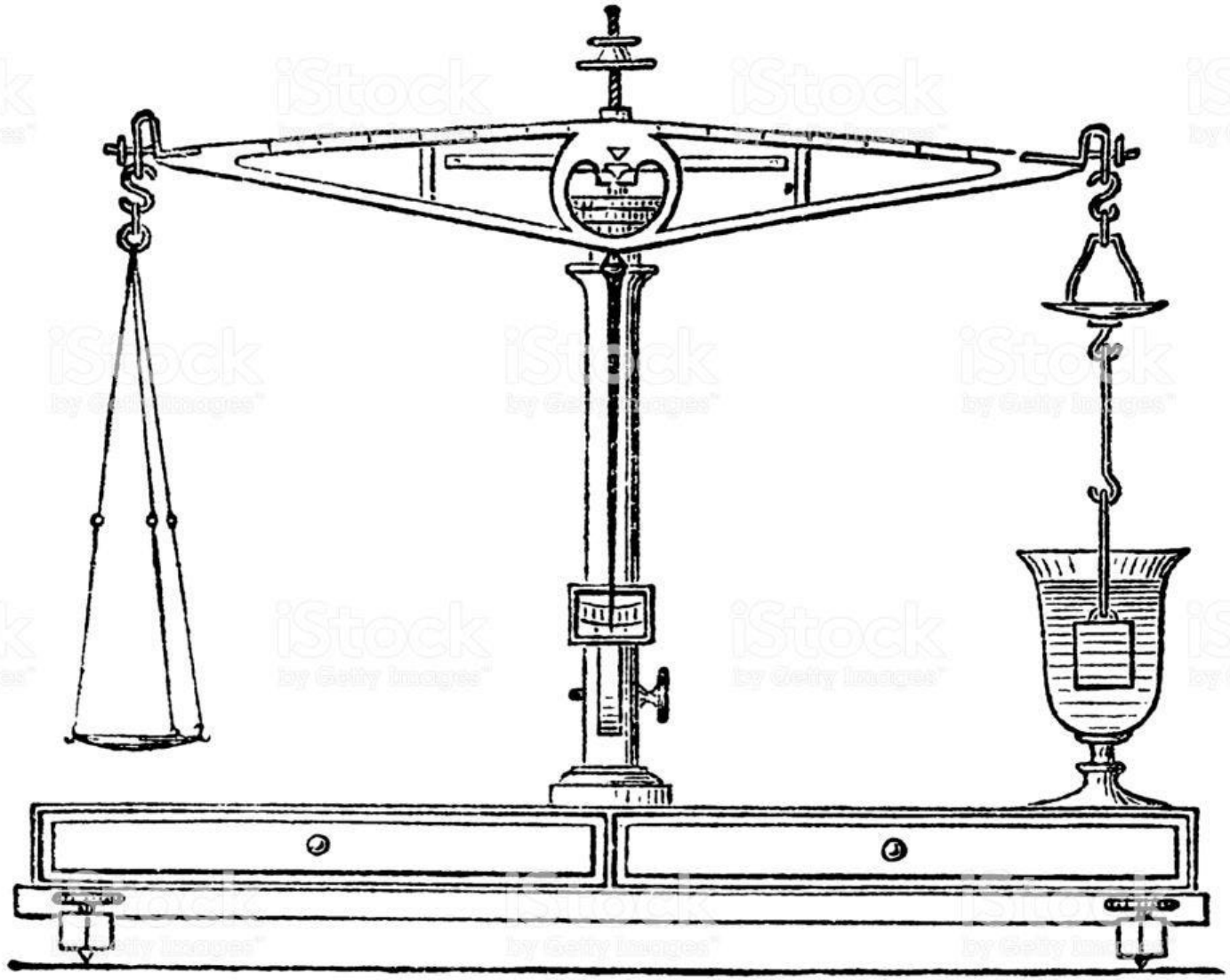
- Studied the works of Archimedes, and Published his first scientific paper, which described a hydrostatic balance/scale that could accurately measure the purity of precious metals, which he called 'The little balance’.

- He also invented a horse-powered water pump based on the Archimedes Screw, which could be used for Crop irrigation.

- People started to take notice of him. He started corresponding with a wealthy local patron, the Marquis Guidebaldo del Monte.

- Eventually he came to the attention of the Grand Duke of Tuscany, Ferdinand 1st de Medici after publishing a second Scientific paper on the Centre of Gravity in Solid bodies.

The Little Balance



Marquis Guidebaldo del Monte

Ferdinand 1st de Medici

University Of Pisa 'Take 2' - Professorship

- 1589 – Appointed Professor Mathematics via his new patron, the Grand Duke of Tuscany

- Mathematics was considered unimportant at the time, the annual salary was 60 Florins a year, about **one tenth of what a Professor of Philosophy** would earn

- Supposedly dropping lead balls of different masses from the Leaning Tower of Pisa to disprove one of Aristotle – **no evidence that this ever happened**.

- Nb - there are several prior experiments by others (see Stevin and De Groote in the Delft Tower, Netherlands) **which had already disproven this**.

Galileo starts to make enemies

- Already considered an upstart at the University of Pisa, and some resented him questioning and disproving some of Aristotle's theories.
- Approached by the Grand Duke of Tuscany to evaluate a new machine for dredging out harbour at Leghorn – invented by one of his sons
- Galileo found that the device had serious deficiencies - **a Dilemma**
- After much deliberation, decided to advise the Duke truthfully of this
- This was confirmed when the device was tried in the Harbour
- Duke very annoyed => unfortunately, a bad career move.
- Galileo eventually resigned from the University of Pisa in 1592.

University of Padua-1592

University of Padua

- Marquis Guidebaldo del Monte managed to establish a professorship at the University of Padua in 1592
- He was now paid 180 Florins a year
- Became a very popular lecturer and attracted large numbers of students,
- There are accounts of outdoor lectures to accommodate crowds of students,
- Also started to branch out as an advisor on military fortifications, siege engines, etc.
- He remained there until 1610 – often referred to it as “the best 18 years of my life”

Financial problems

- Vincenzo (father) had passed away by this time (1591)
- Galileo had five siblings, had promised that he would provide dowries for two of his sisters
- Had to supplement his Professorship wage with private tutoring, income from his various inventions, taking in student boarders and 'consultant' engineering work.

Galileo's Mystery Illness

- *“The clinical history of Galileo, as it turns out from hundred letters he wrote and received, is so informative as to make it possible to delineate the natural history of his body. It is well known that he suffered from recurrent episodes of fever (terzana) since 1606, when he was in Florence as guest of Cristina Lorena for education of the future granduke Cosimo II. By reading signs and symptoms he reported several times, it is clear that he had various diseases (rheumatism, haemorroids, kidney stones, arrhythmias). When in December 1632, at the age of 68, Galileo delayed his journey to Rome claiming sickness, Pope Urban VIII committed 3 physicians to examine him. They reported that Galileo was affected by "pulsus intermittens" (most probably atrial fibrillation), large hernia at risk of rupture, dizziness, diffuse pain, hypochondriacal melancholy as a consequence of the "declining age". It was in February 1637 that he started to have eye disease with lacrimation and progressive loss of sight, which in 10 months led to loose at first the right eye and then also the left one. According to the consultation, asked at distance to Giovanni Trullio on February 1538 in Rome, the diagnosis of blindness due to bilateral uveitis came out. Keeping with the current medicine, the illnes might have been explained in the setting of an immune rheumatic disease (Reiter's syndrome). The cause of Galileo's death, which occurred on 8 January 1642 at the age of 78, is not known since it was not submitted to autopsy. We can speculate cardiac death due to pneumonia complicating congestive heart failure.”*

- In June 1593, Galileo took an afternoon nap with two friends in a “Sala dei Venti”, a room ventilated by nearby caves,
- During the nap, all three men became ill, sources quote either one or both of the other men dying,
- Galileo survived but took a year to recover, but suffered a number of life-long residual symptoms
- These included fevers, joint pains and bouts of chronic fatigue
- As he aged, his vision started to fade – there is a theory that this may have been Chlamydia Pneumonia related or Chlamydia Trachomatis.
- The triad of Arthrits, Conjunctivits & or Uveitis and Urethritis are consistent with Reiter’s syndrome/reactive arthritis, usually from Chlamydia
- As he aged, Galileo suffered from a pulse abnormality (probably Atrial Fibrillation), a large inguinal hernia (at a time when surgery was not possible), and Major Depression, or “Melancholia” as it was known then.

Private life & Children

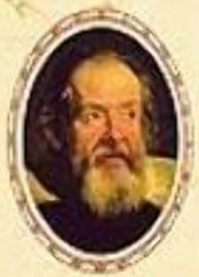
- Galileo Met Marina Gamba in around 1597 in Venice.
- She moved in with him around 1599 in Padua
- Three children born, two daughters (Virginia-born 1600 and Livia -born 1601), and a son, Vincenzo (born 1606).
- When the daughters grew up, they were sent to live in Convents, as their illegitimate birth made them unable to be married.
- Also Galileo could not afford dowries for them
- Vincenzo Jnr was legitimized by the Grand Duke of Tuscany.
- Marina passed away in 1612 aged 52

Surviving letters from Virginia (eldest daughter)

- Approximately 120 letters sent from Virginia (later Sister Marie Celeste) survive and were turned into a very successful book by Dava Sobel and other authors.
- Died at age 33 of dysentery, a year after Galileo passed away.
- Unfortunately none of Galileo's return letters survive, most likely that her property was destroyed by Convent staff when she passed away

FROM THE AUTHOR OF *LONGITUDE*

GALILEO'S DAUGHTER



A Drama of Science, Faith and Love

DAVA SOBEL

'Completely unputdownable'
Ruth Padel, *Guardian*

TO FATHER

The Letters of Sister Maria Celeste to Galileo
1623 ~ 1633

TRANSLATED AND ANNOTATED BY

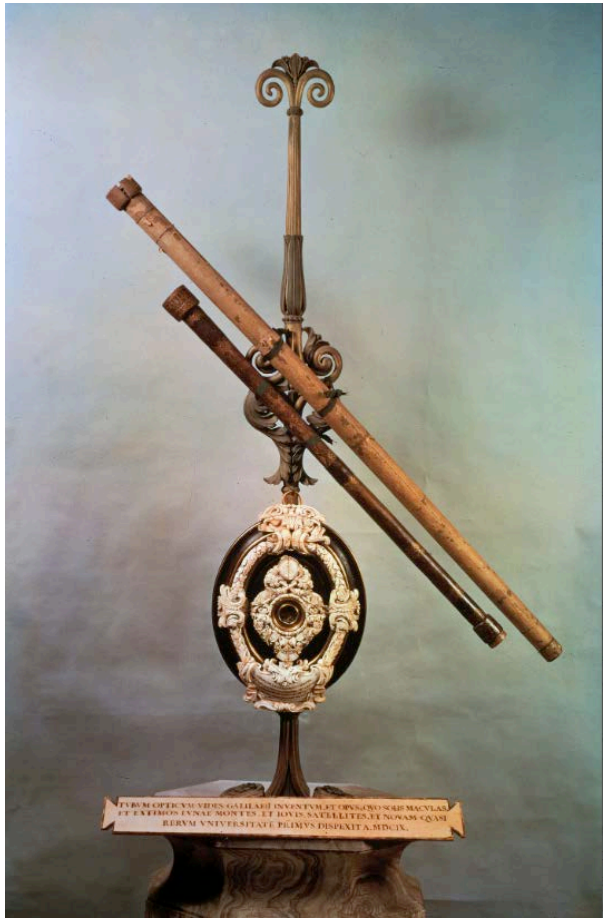
DAVA SOBEL

AUTHOR OF *GALILEO'S DAUGHTER*

'A haunting glimpse into the mind of a highly intelligent and sensitive young woman at the dawn of the Renaissance.'
John Cornwell, *Sunday Times*, on *Galileo's Daughter*

Not a huge fan…

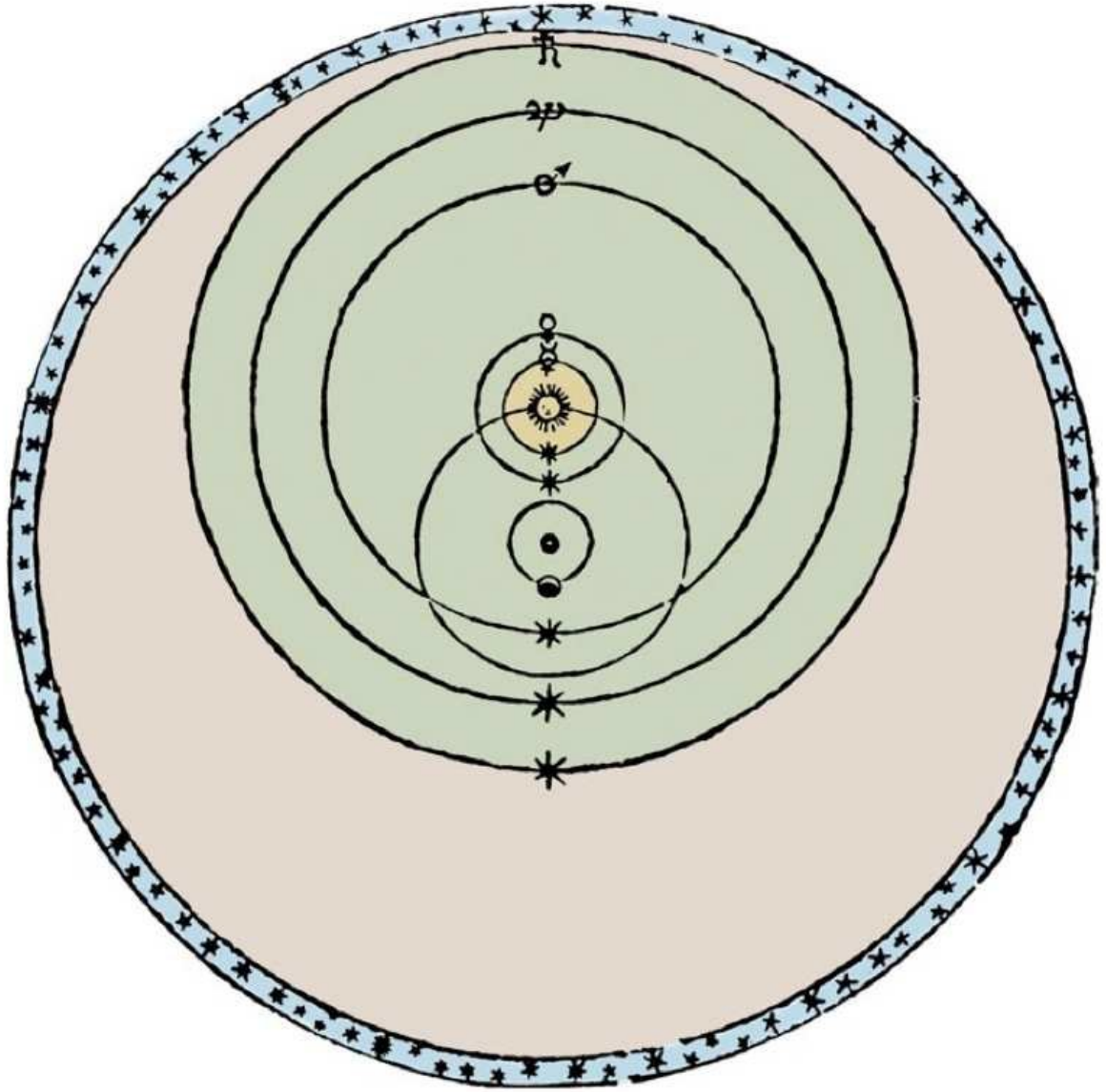
Part 2 - Galileo and the Telescope



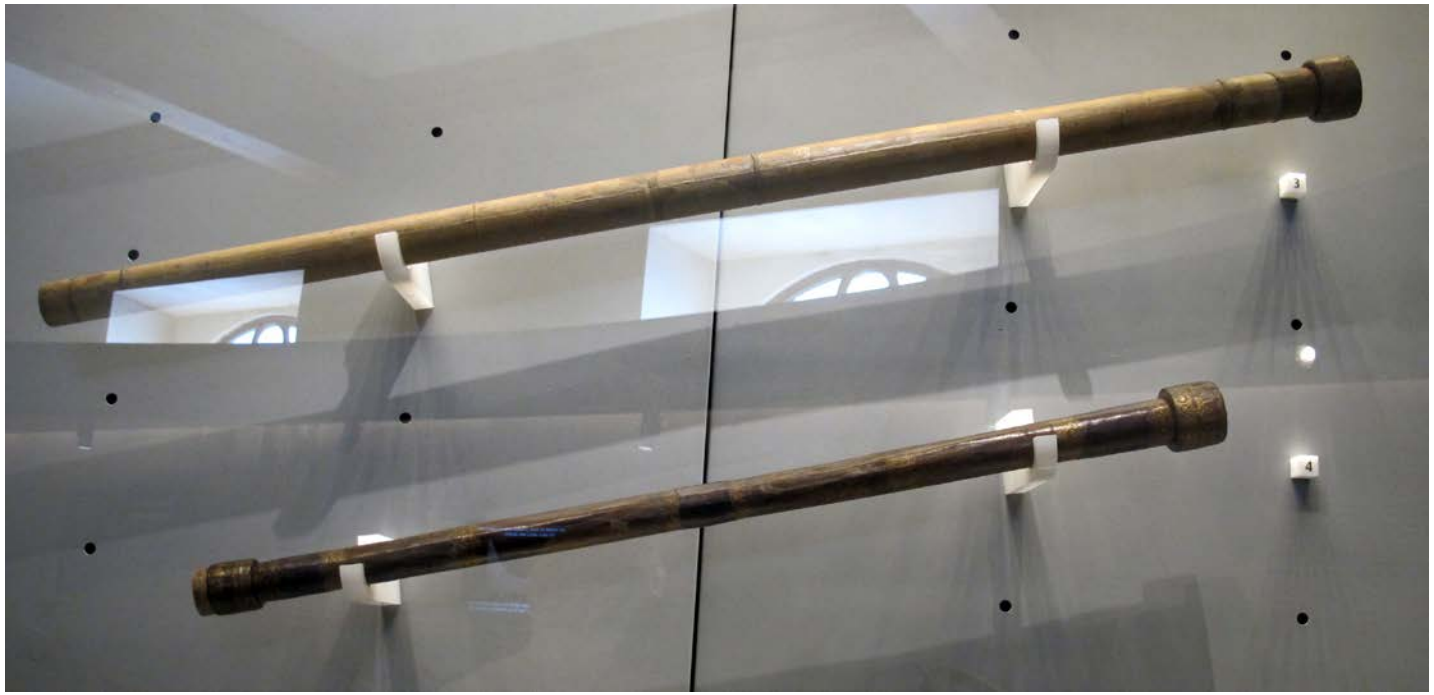
Two telescopes built and used by Galileo (from the Museo Galileo, Florence)

Ptolemaic Model of the world

Tyconic Model of the World



Two of Galileo's surviving telescopes



Advent of the telescope

- First patent for a telescope submitted 0n 02/10/1608 by Dutch spectacle maker Johann Lipperhey (aka Hans Lippershey)
- Similar patent submitted several weeks later by another spectacle maker, Jacob Metius. **Both men were denied a patent.**
- 'The Dutch Perspective Glasses' produced a magnification of 3-4 times
- Galileo heard of this invention in early 1609 - started to experiment and build his own instruments.
- After much experimenation, by late 1609, he had produced a telescope of **30 times** magnification
- As well astrononical use, Galileo made instruments for navigation at sea and for Military use **– created a side business selling these commercially**

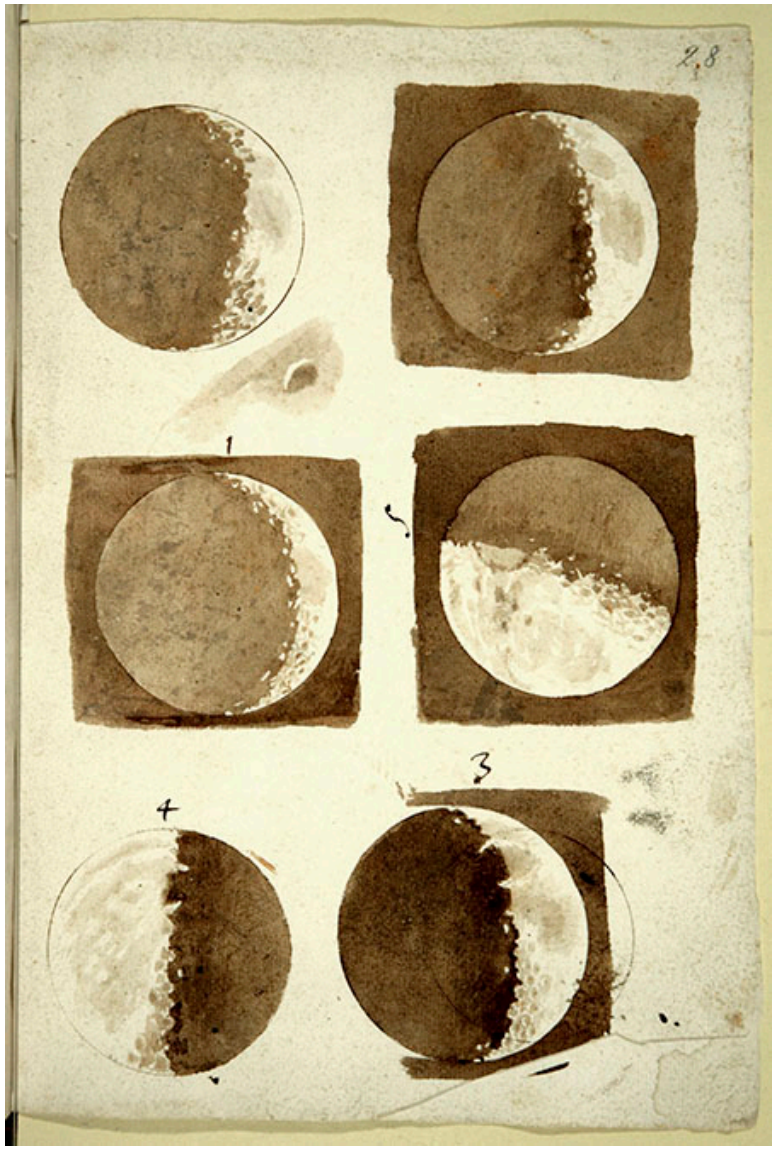
HANS LIPPERHEY,

Secundus Conspiciliorum inventor.

Galileo demonstrates his Telescope to Venetian Lawmakers

First Light – Padua, 1609

First accurate pictures of the moon in history



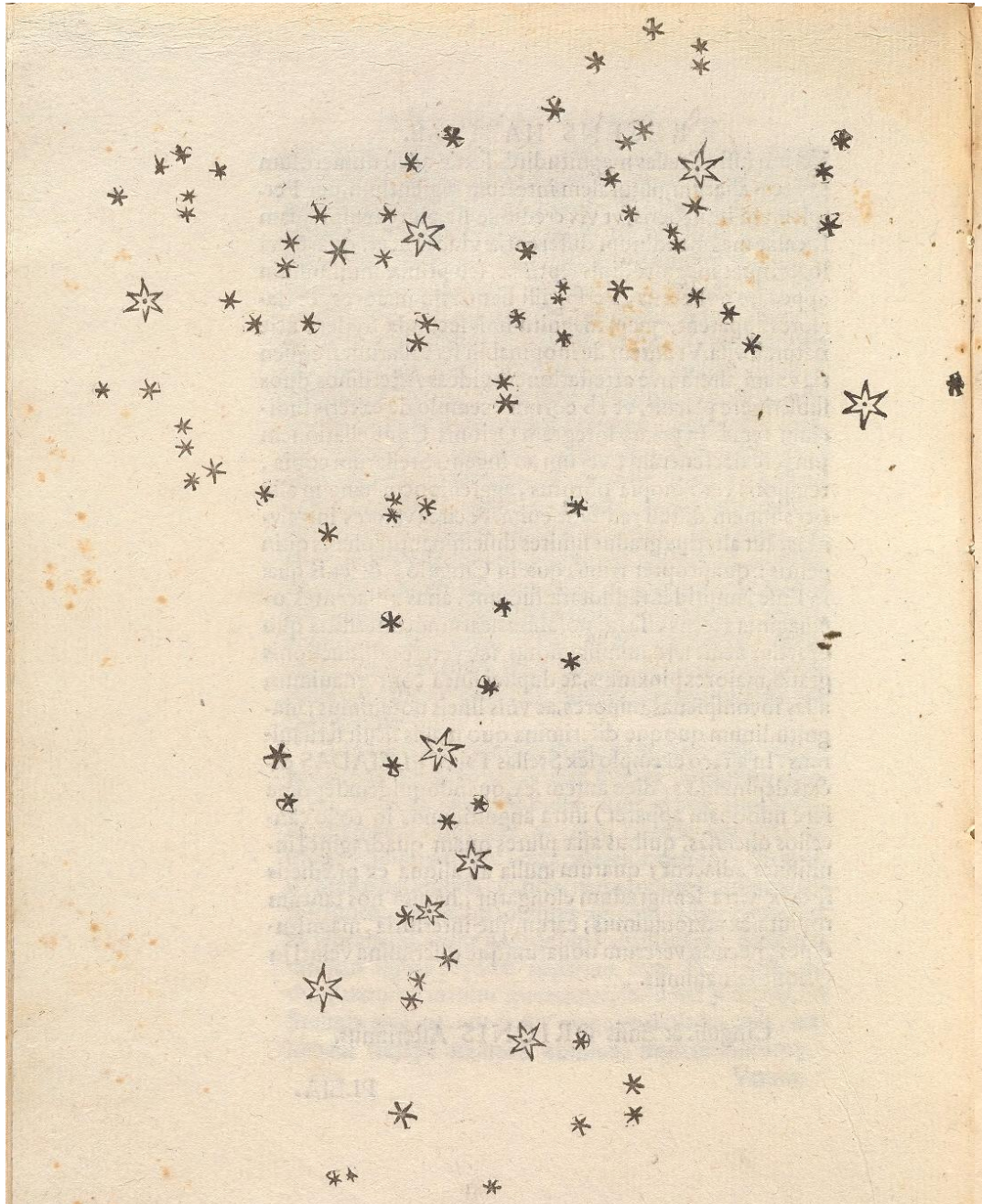
Watercolour painting from a page from Galileo's notebook- 1609

Galileo spent much of 1609 observing and making notes and painting watercolour pictures in his notebook

1610-Siderius Nuncius - ‘The Siderial/Starred Messenger’

- Published in 1610 as a pamphlet.
- Dedicated to the Grand Duke of Tuscany
- Initially 550 copies made, followed by another 350,
- Covered his discoveries of The Moon, Pleidaes, Orion and Jupiter, with diagrams & sketches,
- Was treated with amazement by some but disbelief by others,
- Due to the lack of high quality telescopes, it took some time for his findings to be verified by others,
- Athough more telescopes soon became available, some people refused to look through them (as per letters from Galileo to Kepler).

An amalgam of some of the moon sketches featured in ‘Siderius Nuncius’



PLEIADVM CONSTELLATIO.

Quòd tertio loco à nobis fuit obſeruatum, eſt ipſiuſmet LACTEI Circuli eſſentia, ſeu materies, quam Perſpicilli beneficio adeò ad ſenſum licet intueri, vt & altercationes omnes, quæ per tot ſæcula Philoſophos excruciarunt ab oculata certitudine dirimantur, nosque à verboſis diſputationibus liberemur. Eſt enim GALAXYA nihil aliud, quam innumerarum Stellarum coaceruatim conſitarum congeries; in quamcunq; enim regionem illius Perſpicillum dirigas, ſtatim Stellarum ingens frequentia ſe ſe in conſpectum profert, quarum complures ſatis magnæ, ac valde conſpicuæ videntur; ſed exiguarum multitudo prorſus inexplorabilis eſt.

At cum non tantum in GALAXYA lacteus ille candor, veluti albicantis nubis ſpectetur, ſed complures conſimilis coloris areolæ ſparſim per æthera ſubfulgeant, ſi in illarum quamlibet Specillum conuertas Stellarum conſtipatarum

cętum

NEBVLOSA ORIONIS.

NEBVLOSA PRÆSEPE.

7th Jan 1610 onwards

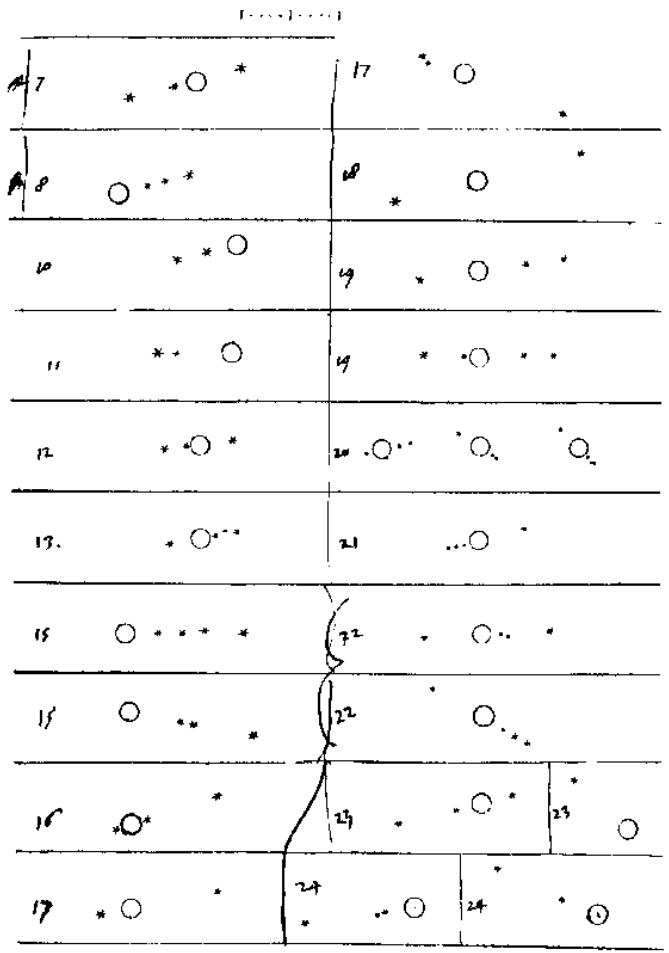
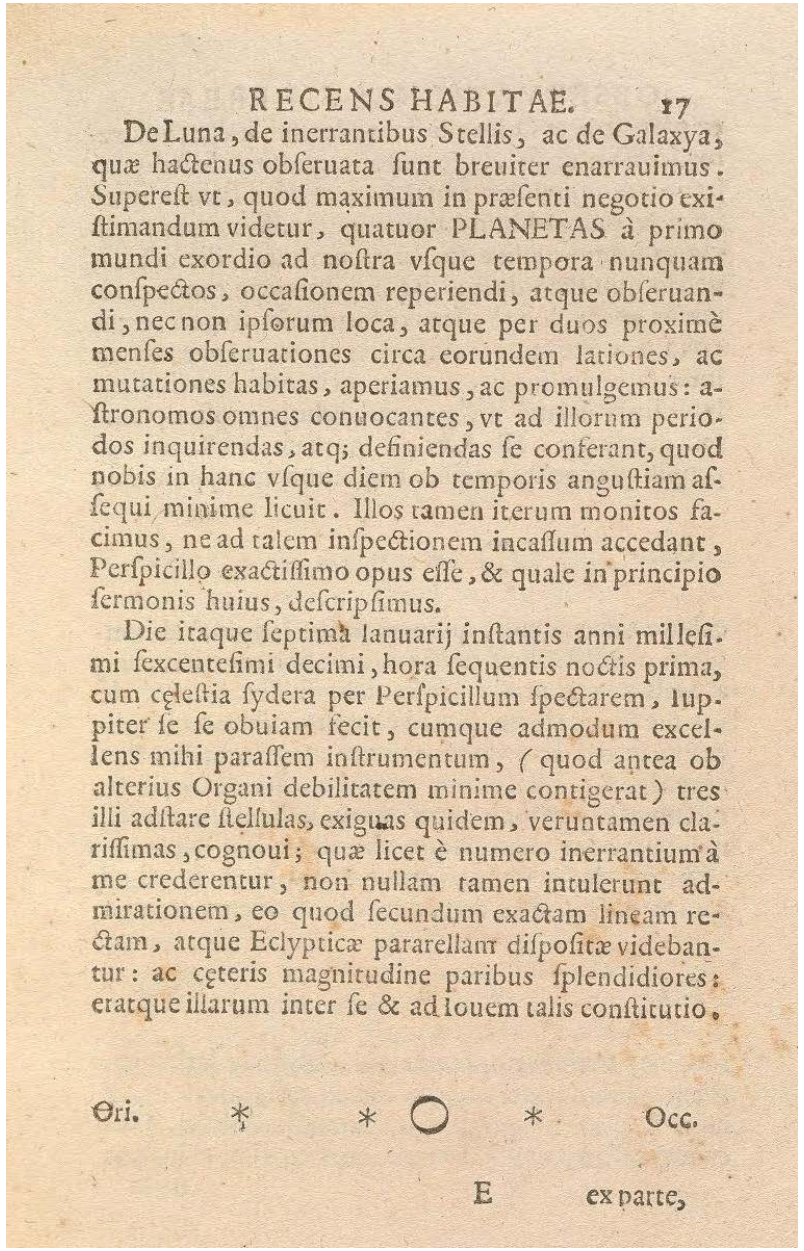


Fig.	Date.	East.	West.
1	Jan. 7		
2	8		
3	10		
4	11		
5	12		
6	13		
7	15		
8	15		
9	16		
10	17		

Jupiter – Siderius Nuncius



RECENS HABITAE. 17

De Luna, de inerrantibus Stellis, ac de Galaxya, quæ hactenus obſeruata ſunt breuiter enarrauimus. Supereſt vt, quod maximum in præſenti negotio exiſtimandum videtur, quatuor PLANETAS à primo mundi exordio ad noſtra vſque tempora nunquam conſpectos, occaſionem reperiendi, atque obſeruandi, nec non ipſorum loca, atque per duos proximè menſes obſeruationes circa eorundem lationes, ac mutationes habitas, aperiamus, ac promulgemus: aſtronomos omnes conuocantes, vt ad illorum periodos inquirendas, atq; definiendas ſe conferant, quod nobis in hanc vſque diem ob temporis anguſtiam aſſequi minime licuit. Illos tamen iterum monitos facimus, ne ad talem inſpectionem incaſſum accedant, Perſpicillo exactiſſimo opus eſſe, & quale in principio ſermonis huius, deſcripſimus.

Die itaque ſeptimâ Ianuarij inſtantis anni milleſimi ſexcenteſimi decimi, hora ſequentis noctis prima, cum cęleſtia ſydera per Perſpicillum ſpectarem, Iuppiter ſe ſe obuiam fecit, cumque admodum excellens mihi paraſſem inſtrumentum, (quod antea ob alterius Organi debilitatem minime contigerat) tres illi adſtare ſtellulas, exiguas quidem, veruntamen clariſſimas, cognoui; quæ licet è numero inerrantium à me crederentur, non nullam tamen intulerunt admirationem, eo quod ſecundum exactam lineam rectam, atque Eclypticæ pararellam diſpoſitæ videbantur: ac cęteris magnitudine paribus ſplendidiores: eratque illarum inter ſe & ad Iouem talis conſtitutio,

Ori. ♃ * ○ * Occ.

ex parte ſcilicet Orientali duæ aderant Stellæ, vna verò Occaſum verſus. Orientalior atque Occidentalis, reliqua paulo maiores apparabant, de diſtantia inter ipſas & Iouem minime ſollicicus fui; fixæ enim vti diximus primo creditæ fuerunt; cum autem die octaua, neſcio quo Fato ductus, ad inſpectionem eandem reuerſus eſſem, longè aliam cõſtitutionem reperi; erant enim tres Stellulæ occidentales omnes à Ioue, atque inter ſe quam ſuperiori nocte viciniores, paribuſque interſtitijs mutuò diſſeparatæ, veluti appoſita præſefert delineatio. Hic licet ad mutuam Stellarum appropinquationem minimè cogitationem appuliſſem,

Ori. ○ * * * Occ.

exitare tamen cæpit, quonam pacto Iuppiter ab omnibus prædictis fixis poſſet orientalior reperiri, cum à binis ex illis pridie occidentalis fuiſſet: ac proinde veritus ſum ne forte, ſecus à computo aſtronomico, directus foret, ac propterea motu proprio Stellas illas anteuertiſſet: quapropter maximo cum deſiderio ſequentem expectaui noctem; verum à ſpe fruſtratus fui, nubibus enim vndiquaque obductum fuit cælum.

At die decima apparuerunt Stellæ in eiuſmodi ad Iouem poſitu: duæ enim tantum, & orientales ambæ

Ori. * * ○ Occ.

aderant, tertia, vt opinatus fui, ſub Ioue latitante. Erant pariter veluti antea in eadem recta cum Ioue, ac iuxta Zodiaci longitudinem adamuſſim locatæ. Hæc cum vidiſſem, cumque mutationes conſimiles in Ioue nulla

nulla ratione reponi poſſe intelligerem, atque inſuper ſpectatas Stellas ſemper eaſdem fuiſſe cognoſcerem, (nullæ enim aliæ, aut præcedentes, aut conſequentes intra magnum interuallum iuxta longitudinem Zodiaci aderant) iam ambiguitatem in admirationem permutans, apparentem commutationem non in Ioue, ſed in Stellis adnotatis repoſitã eſſe comperi; ac proinde oculatè, & ſcrupulosè magis deinceps obſeruandum fore ſum ratus.

Die itaq; vndecima eiuſcemodi conſtitutionem vidi:

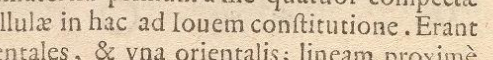
Ori. * * ○ Occ.

Stellas ſcilicet tantum duas orientales; quarum media triplo diſtabat à Ioue, quam ab orientaliori: eratque orientalior duplo ferè maior reliqua, cum tamen antecedenti nocte æquales fermè apparuiſſent. Statutum ideò, omnique procul dubio à me decretum fuit, tres in cœlis adeſſe Stellas vagantes circa Iouem, inſtar Veneris, atque Mercurij circa Solem: quod tandem luce meridiana clarius in alijs poſtmodum compluribus inſpectionibus obſeruatũ eſt; ac non tantum tres, verum quatuor eſſe vaga Sydera circa Iouem ſuas circumuolutiones obeuntia; quorum permutationes exactius conſequenter obſeruatas ſubſequens narratio miniſtrabit; interſtitia quoque inter ipſa per Perſpicillum, ſuperius explicata ratione, dimetitus ſum: horas inſuper obſeruationum, præſertim cum plures in eadem nocte habitæ fuerunt appoſui; adeo enim celeres horum Planetarum extant reuolutiones, vt horarias quoque differentias plerunque liceat accipere.

Die igitur duodecima, hora ſequentis noctis prima hac ratione diſpoſita Sydera vidi. Erat orientalior

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.

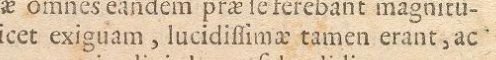
Die decimatertia primum à me quatuor conſpectæ fuerunt Stellulæ in hac ad Iouem conſtitutione. Erant tres occidentales, & vna orientalis; lineam proximè



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;



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 huiuſ-

cemodi 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.

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

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 e. min: 30. huiuſmodi fuit configuratio. Stella vna tantum orientalis à

Ioue

Jupiter's moons

- Named by Galileo, the Medicean moons, in honour of the four Medici Brothers who were his Patrons - Cosimo, Francesco, Carlo, and Lorenzo.

- Simon Marius, German Astronomer claimed to have seen the Medici Moons before Galileo on the 29th December (Julian Calender). He published an angry rebuttal of Galileo's discovery, claiming to have found the moons several weekd earlier, but Galileo (using the Gregorian Calender) indicated that his first viewing on 7th January, was the equivalent of 28th December – ONE DAY prior to Marius.

- NB Marius was a student at the University of Padua while Galileo was there, tutored by a another man, Baldasarre Capra, who was involved in a plagiarism dispute with Galileo.

- For aproximately two centuries, Jupiters moons were known as the Medici Moons, although (ironically) we now know them the names that Simon Marius gave them (Io, Europa, Ganymede and Callisto).

- It would seem likely Galileo wondered if Jupiter was like a mini-Copernican system, and that the craters, seas and mountains seen on the Moon started him considering the moons similarities to Earth.

Jupiter's moons (Continued)

- Simon Marius was the first to create an Ephermis for Juipiter’s moons.
- The Jovian Moon ephermis was used to try and solve the problem of time-keeping and longitude calculation,
- However, light takes 33 minutes to reach us from Jupiter at it’s opposition and 54 minutes to reach us at it’s furthest point from us each year.
- Navigators tables could therefore be as much as 20 minutes out of time, making time-keeping unreliable.

1612 – Letters on Sunspots

- The letters were a collection of the back-and-forth dialogue between Gaileo and another astronomer, Christoph Scheiner
- The pamphlet included three letters written by Galileo
- May 1612
- August 1612
- December 1612

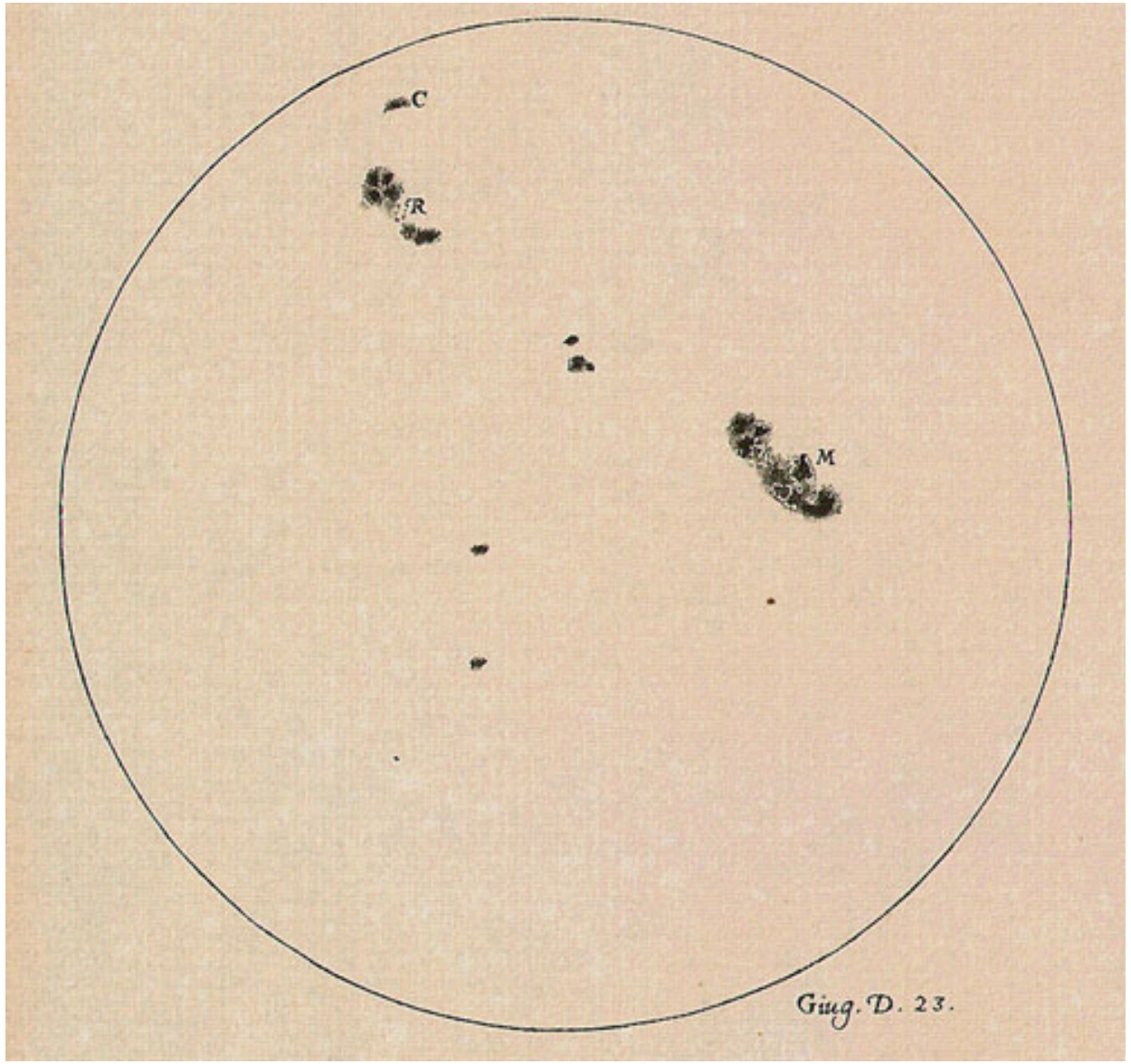

ISTORIA
E DIMOSTRAZIONI
INTORNO ALLE MACCHIE SOLARI
E LORO ACCIDENTI
COMPRESE IN TRE LETTERE SCRITTE
ALL'ILLVSTRISSIMO SIGNOR
MARCO VELSERI LINCEO
DVVMVIRO D'AVGVSTA
CONSIGLIERO DI SVA MAESTA CESAREA
DAL SIGNOR
GALILEO GALILEI LINCEO
Nobil Fiorentino, Filosofo Matematico Primario del Serenis.
D. COSIMO II. GRAN DVCA DI TOSCANA.
Si aggiungono nel fine le Lettere, e Disquisitioni del Sig.to Apelle.
IN ROMA, Appresso Giacomo Mascardi. MDCXIII.
CON LICENZA DE' SVPERIORI.

What was revealed in the letters ?

- The collected Letters documented the dialogue between Schenier and Galileo
- Scheiner was a Jesuit Priest and published under an alias – “Appelles” – he was careful to avoid antagonising his fellow priests
- Scheiner argued that sunspots were satellites around Jupiter.
- Galileo countered that they were nothing like satellites and likened them to clouds on Earth. He noted that they changed shape and shortened near the edge of the sun
- In later letters, the Phases of Venus and Saturn’s unusual shape were also discussed
- Copernican theory v’s Ptolemaic/Aristotlean theory was also discussed between the two, with Galileo arguing in favour of the Copernican.

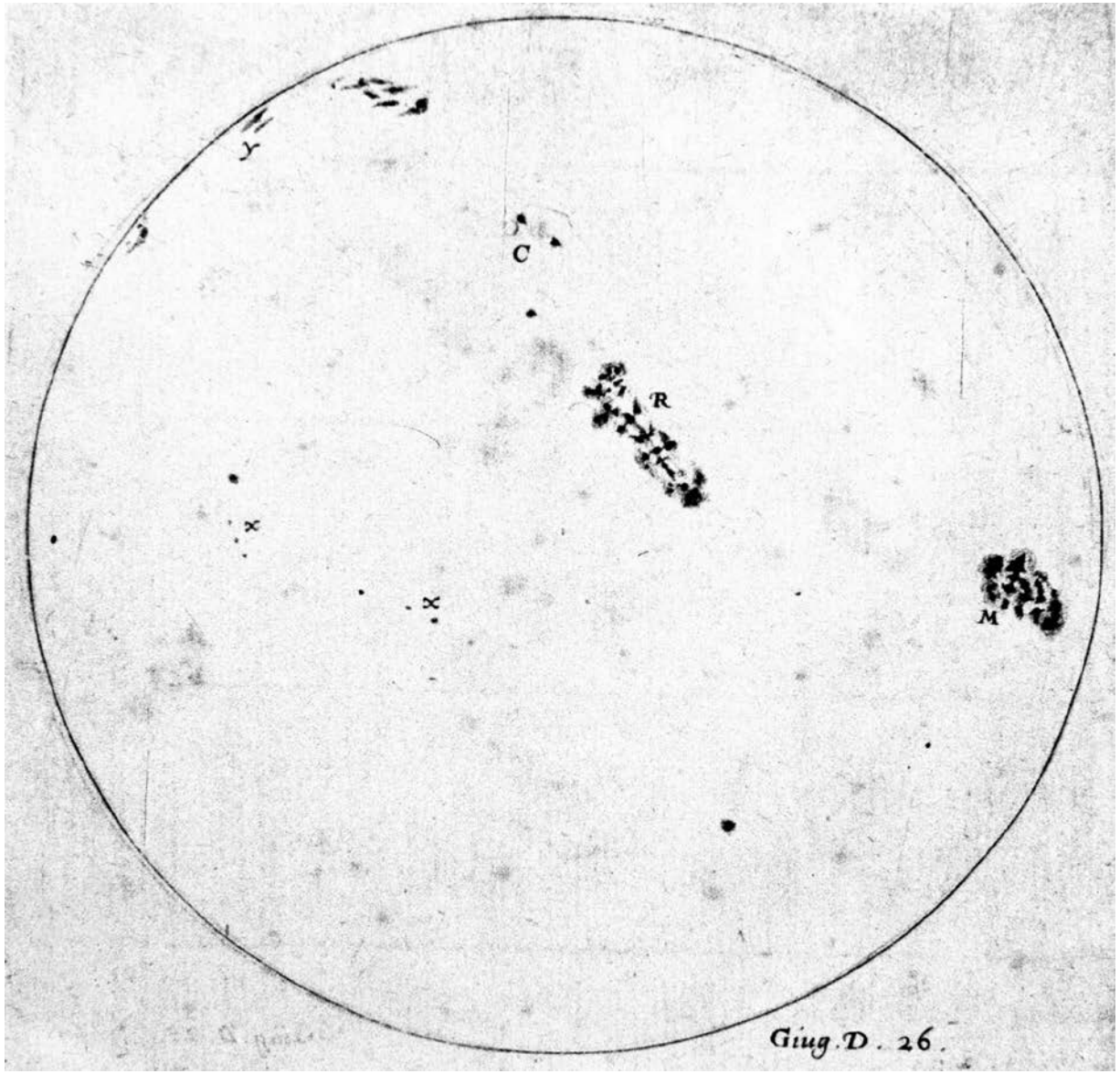

DVVMVIRO D'AVGVSTA
CONSIGLIERO DI SVA MAESTA CESAREA
DAL SIGNOR
GALILEO GALILEI LINCEO
Nobil Fiorentino, Filoſofo, e Matematico Primario del Sereniſs.
D. COSIMO II. GRAN DVCA DI TOSCANA.
Si aggiungono nel fine le Lettere, e Diſquiſizioni del finto Apelle.
IN ROMA, Appreſſo Giacomo Maſcardi. MDCXIII.
CON LICENZA DE' SVPERIORI.

One of Gailileo's drawings from his Helioscope in "Letters on Sunspots"

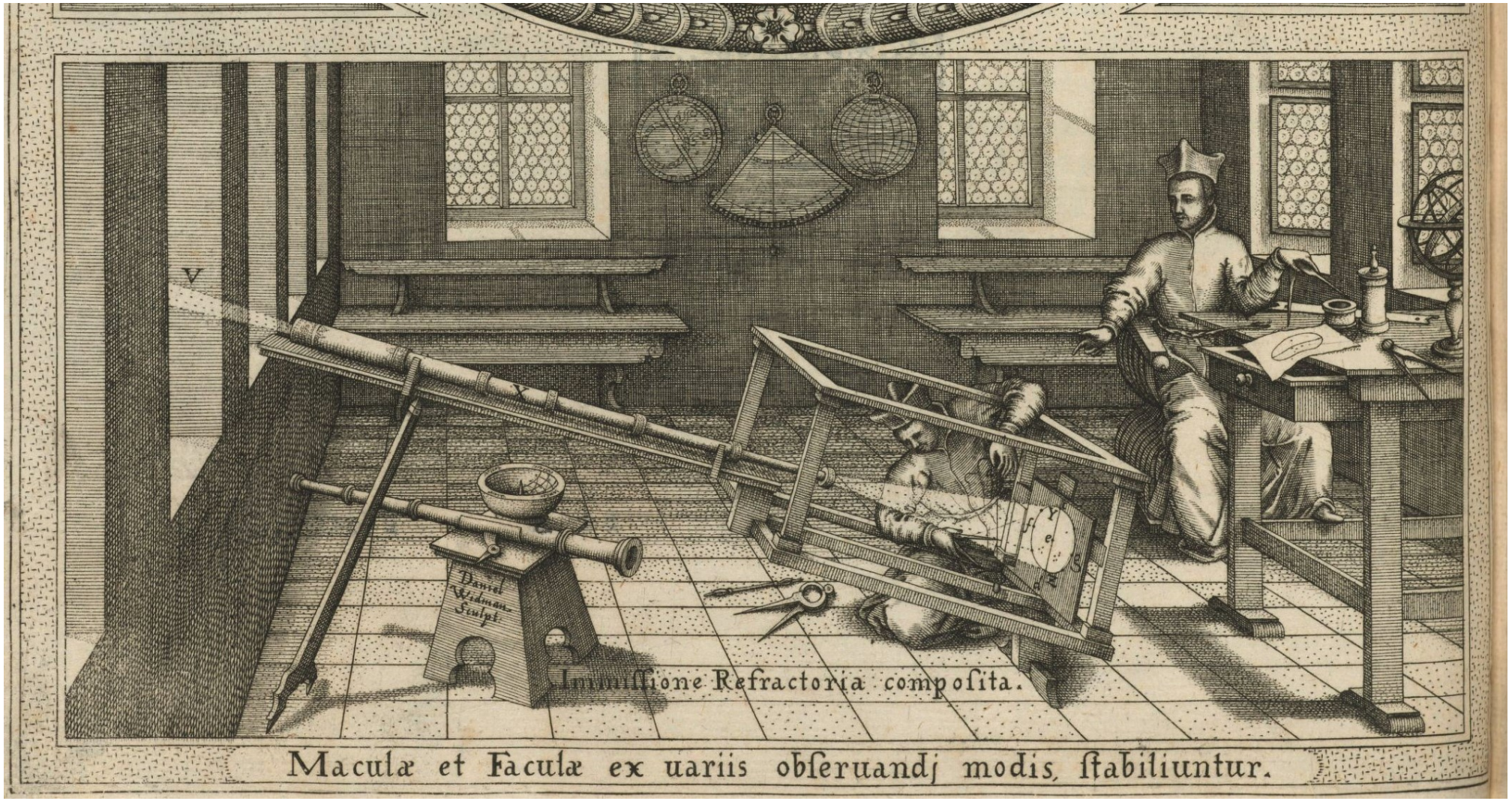


Another of Galileo's drawings of sunspots

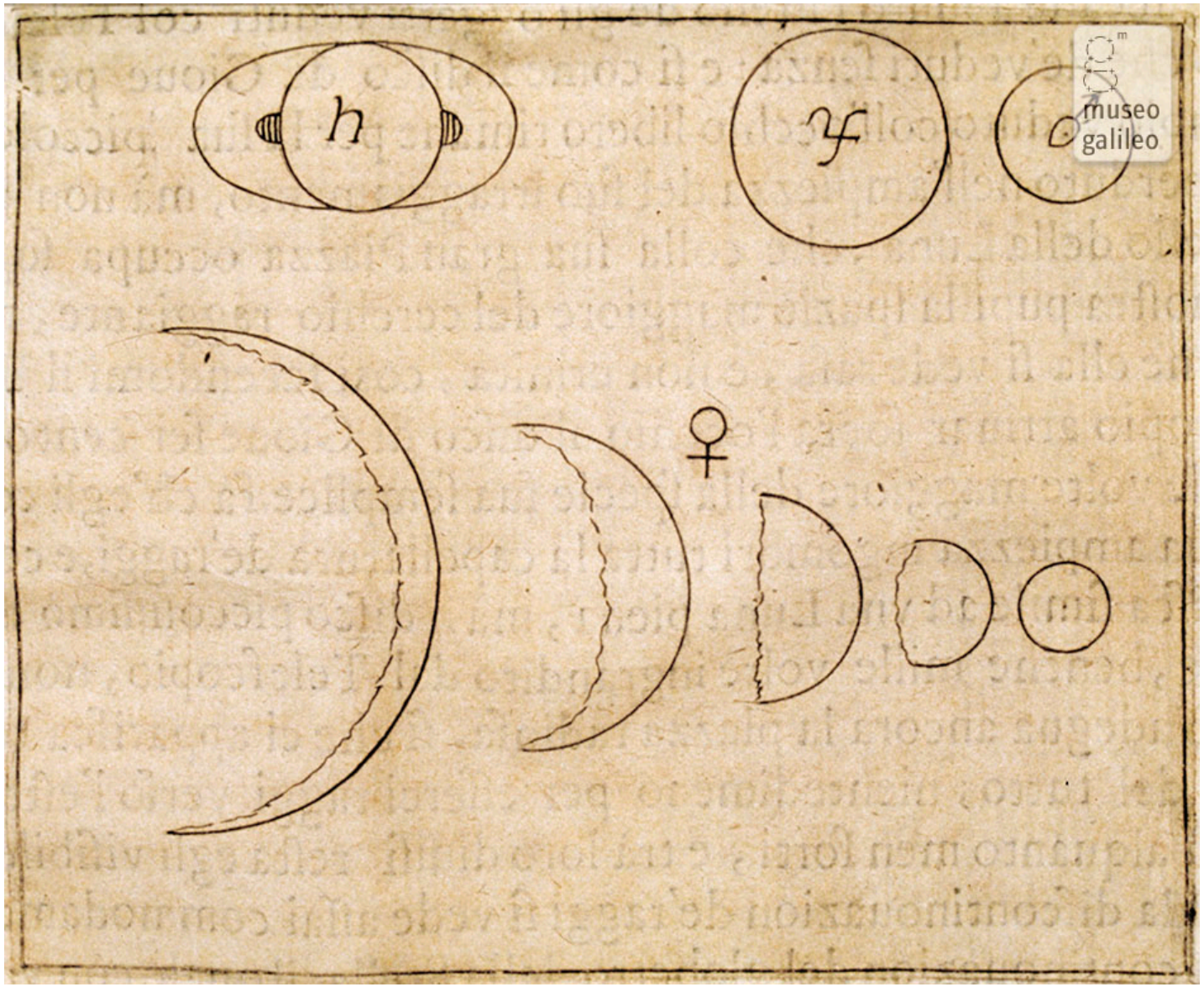
Note top left - perspective



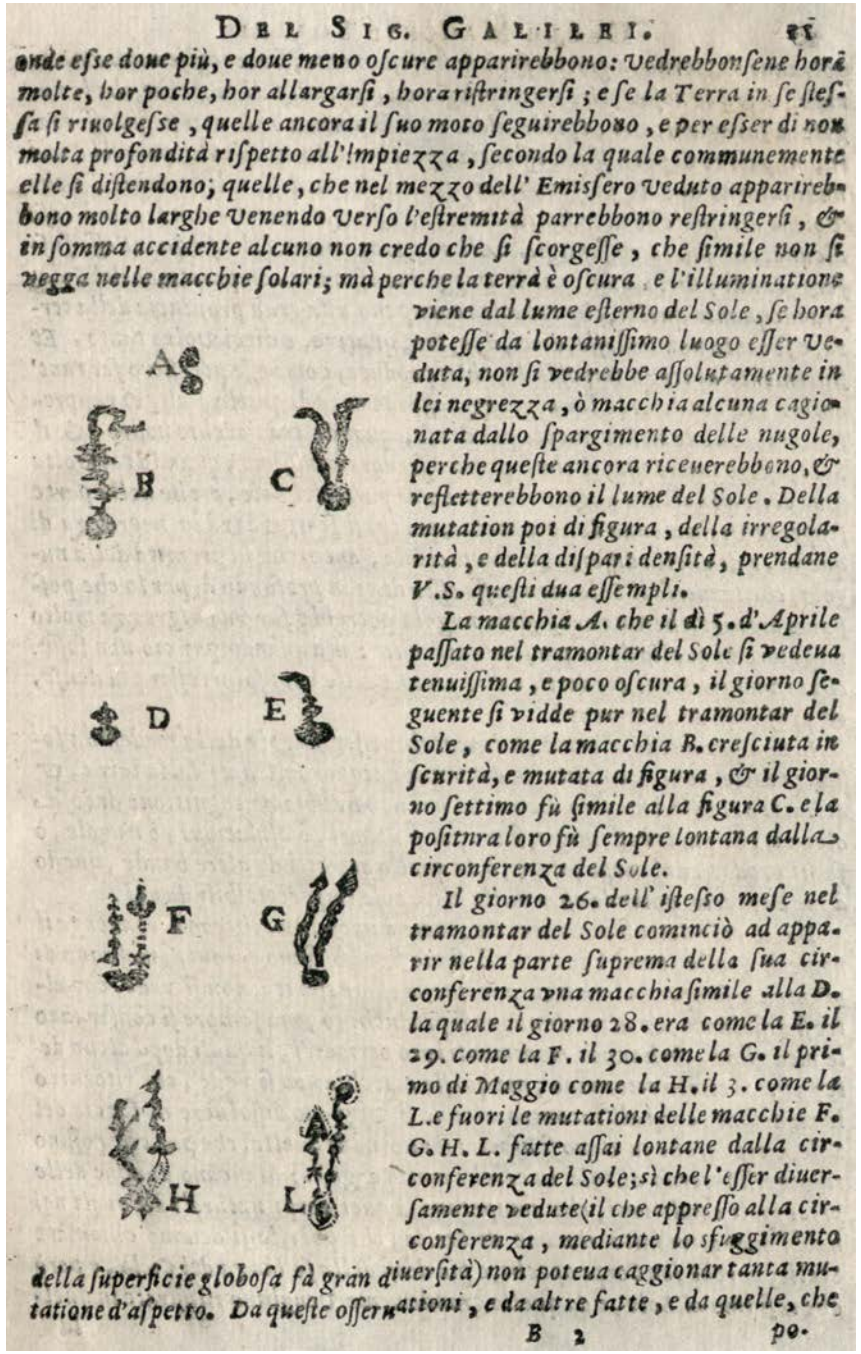
Typical mediaeval heliostat of the day



Some of his drawings of Venus and Saturn



One of Galileo's diagrams of changing sunspots (arguing against them being satellites of the Sun)



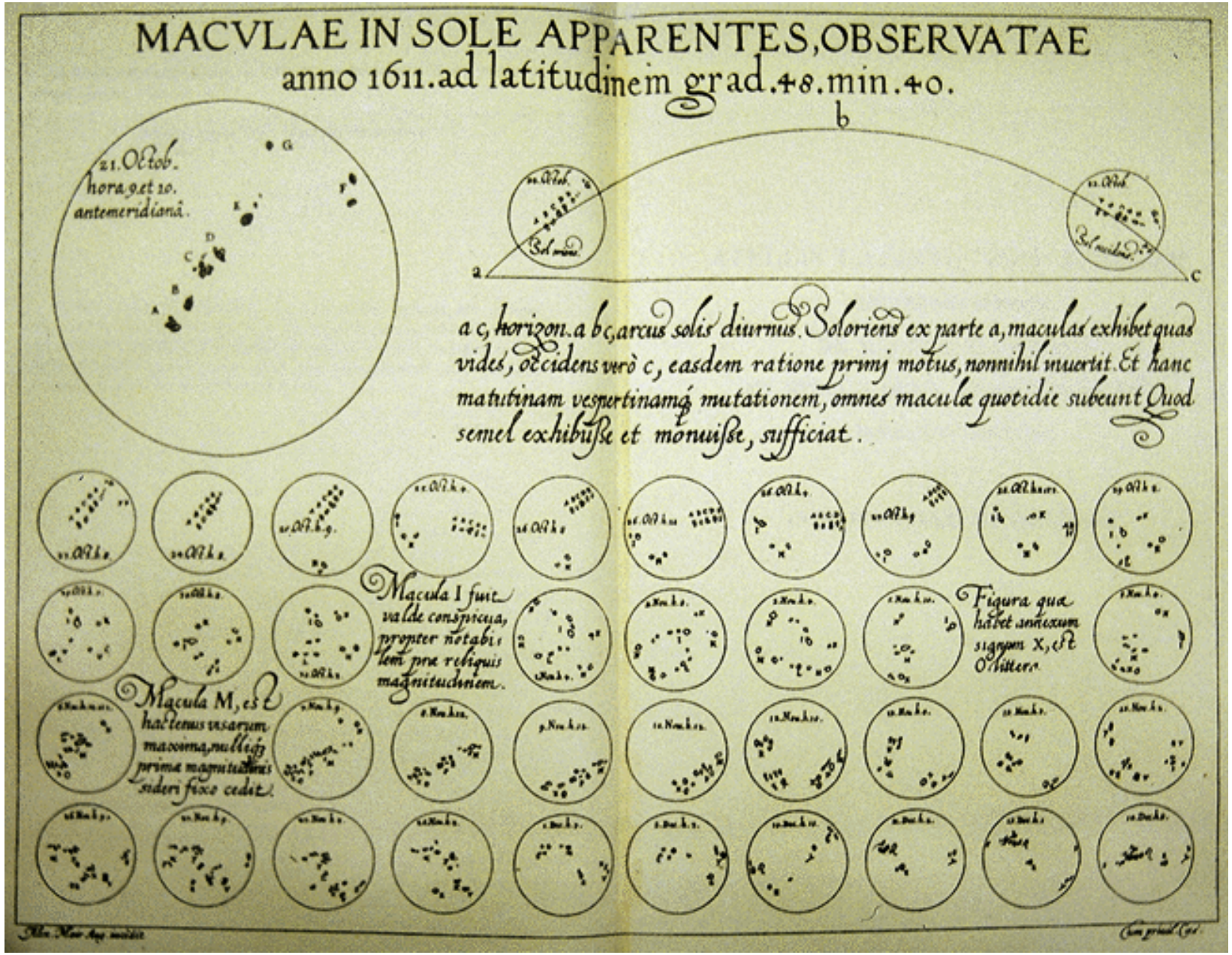
DEL SIG. GALILEI. 81

onde esse done più, e done meno oscure apparirebbono: Vedrebbonsene hora molte, hor poche, hor allargarsi, hora ristringersi; e se la Terra in se stessa si rivolgesse, quelle ancora il suo moto seguirebbono, e per esser di non molta profondità rispetto all'Impiezza, secondo la quale communemente elle si distendono; quelle, che nel mezzo dell' Emisfero veduto apparirebbono molto larghe venendo verso l'estremità parrebbono restringersi, & in somma accidente alcuno non credo che si scorgesse, che simile non si vegga nelle macchie solari; mà perche la terrà è oscura, e l'illuminatione viene dal lume esterno del Sole, se hora potesse da lontanissimo luogo esser Veduta, non si vedrebbe assolutamente in lei negrezza, ò macchia alcuna cagionata dallo spargimento delle nugole, perche queste ancora riceverebbono, & refletterebbono il lume del Sole. Della mutation poi di figura, della irregolarità, e della dispari densità, prendane V.S. questi dua essempli.

La macchia A. che il dì 5. d'Aprile passato nel tramontar del Sole si vedeua tenuissima, e poco oscura, il giorno seguente si vidde pur nel tramontar del Sole, come la macchia B. cresciuta in scurità, e mutata di figura, & il giorno settimo fù simile alla figura C. e la positura loro fù sempre lontana dalla circonferenza del Sole.

Il giorno 26. dell' istesso mese nel tramontar del Sole cominciò ad apparir nella parte suprema della sua circonferenza vna macchia simile alla D. la quale il giorno 28. era come la E. il 29. come la F. il 30. come la G. il primo di Maggio come la H. il 3. come la L. e fuori le mutationi delle macchie F. G. H. L. fatte assai lontane dalla circonferenza del Sole; sì che l'esser diuersamente vedute (il che appresso alla circonferenza, mediante lo sfuggimento della superficie globosa fà gran diuersità) non poteua caggionar tanta mutatione d'aspetto. Da queste osserv[illegible]ationi, e da altre fatte, e da quelle, che

Another diagram of changing sunspots



A further one of Galileo's sketches at the time

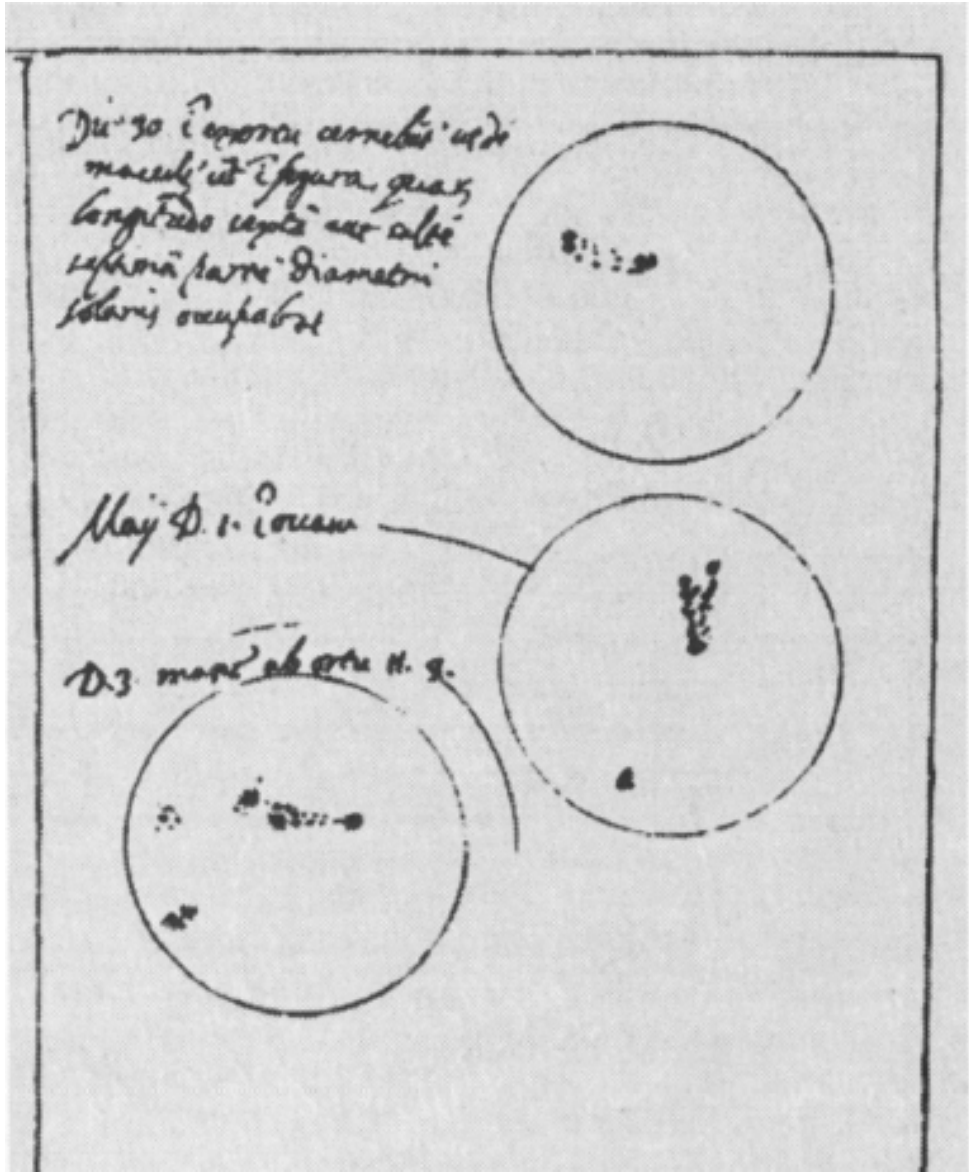
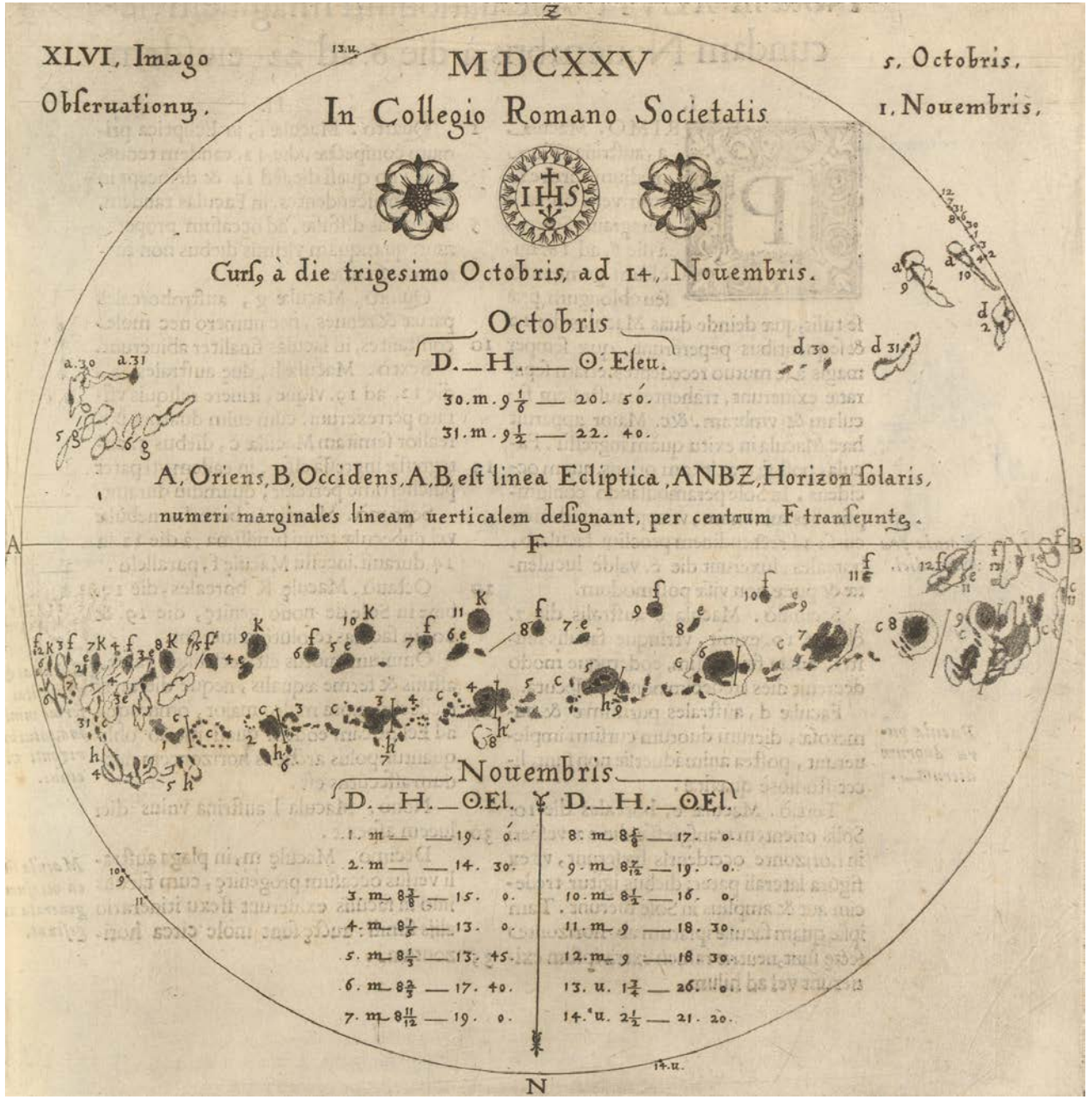


Diagram from one of Christoph Scheiner's letters



1612 – Galileo and Neptune

- **Melbourne Physicst Professor David Jamieson has written a research paper postulating that Galileo recorded Neptune amongst his notebook drawings in 1612**

- **Possibly without realising that he was recording another planet**

- **But possibly he may have realised…**

1612 – Galileo and Neptune (cont'd)

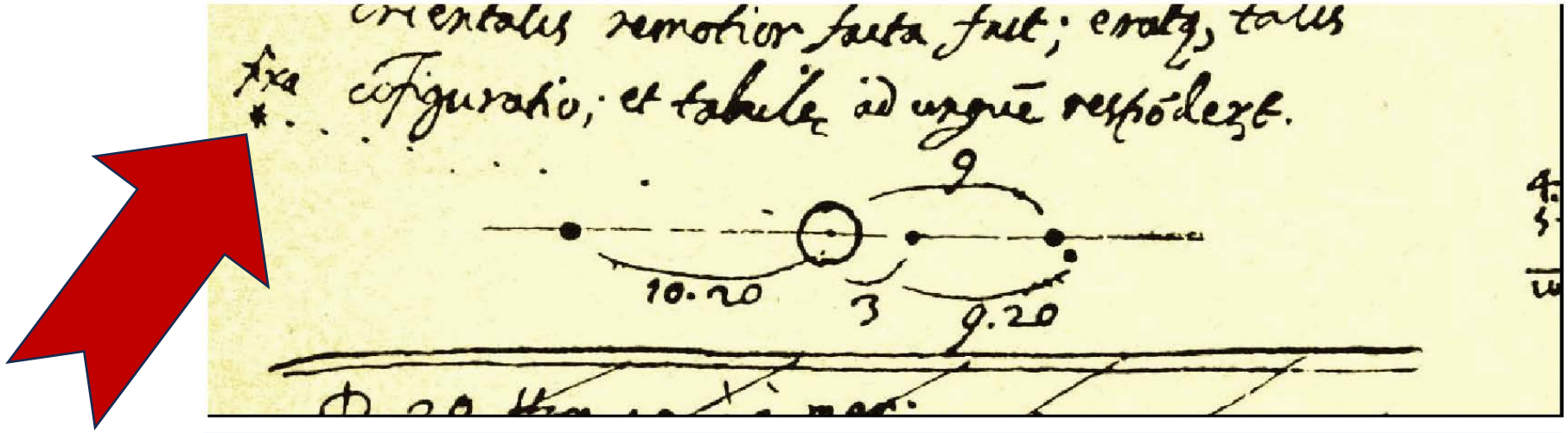


Fig 1 Galileo's notebook for December 28 1612. The object labelled "fixa" on the left is Neptune. Image credit by kind permission of the Ministero per i Beni e le Attività Culturali della Repubblica Italiana/Biblioteca Nazionale Centrale di Firenze

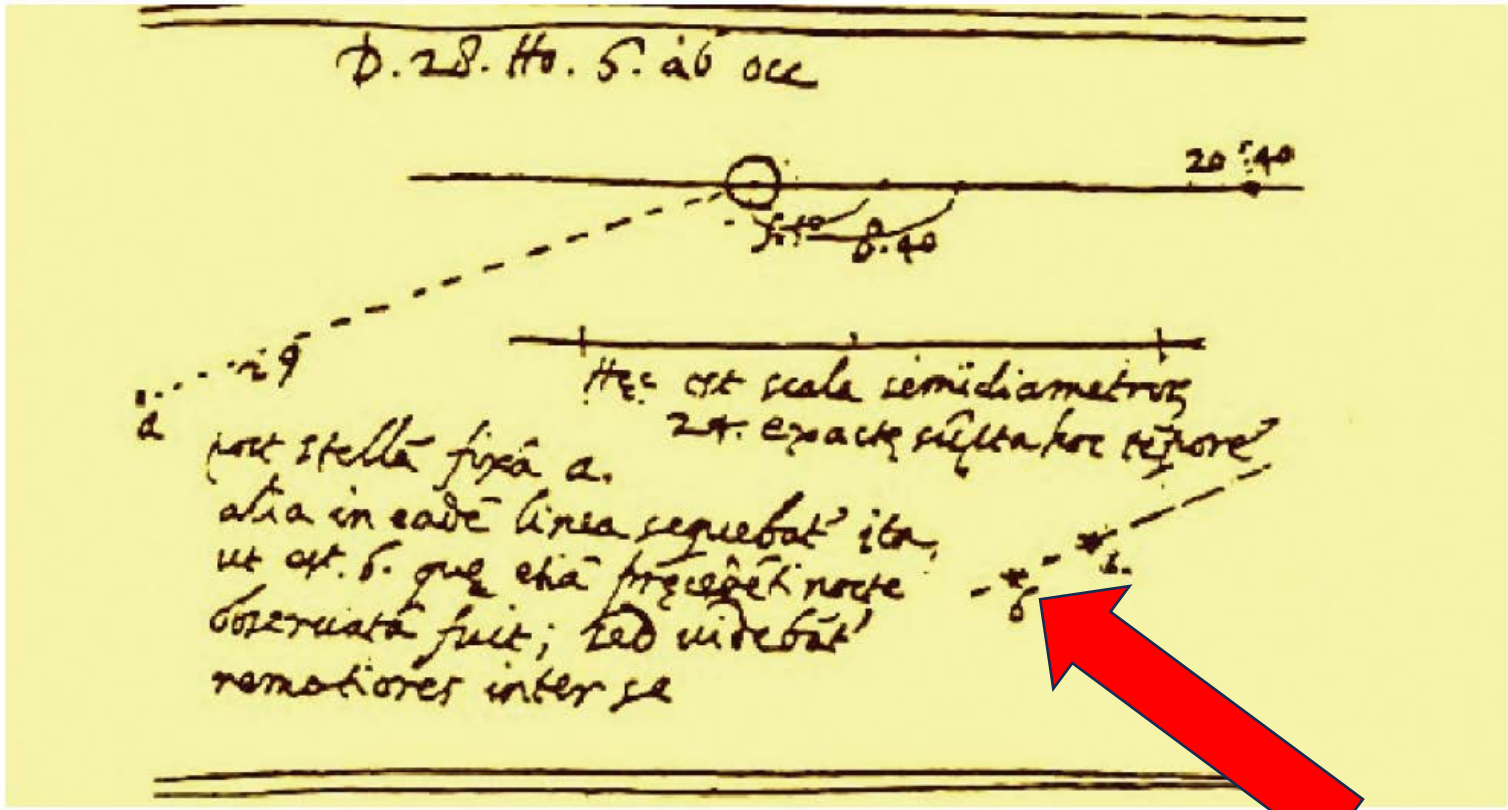


Fig 3 Galileo's notebook from January 28 1613: The object labelled "**b**" on the inset lower right is Neptune. Image credit by kind permission of the Ministero per i Beni e le Attività Culturali della Repubblica Italiana/Biblioteca Nazionale Centrale di Firenze.

From 1613 to 1632

- Galileo became ‘a celebrity’ and was very popular with Royalty
- He left his Mathematics Professorship in Pisa in 1610, but continued tutoring privately,
- Continued selling his inventions including his telescopes, military compasses, water pumps, etc.,
- Employed a tradesman fulltime to manufacture his inventions for sale,
- Continued as a consultant adviser for military fortification design,
- Wrote two books – ‘The Assayer’ (1618), and ‘A Dialogue Concerning Two Chief World Systems’ (1632)
- Did research regarding mechanics and gravity with a long-term view to writing a book on those subjects (NOTE … foreshadowing his acclaimed final scientific book “ Two New Sciences”)

Making more enemies!

- **AI search - first line** – Notes that Galileo could be “quite sarcastic, pugnacious and vain” when arguing against his esteemed scientific colleagues. Also as seen below, at times he tended to stick to his scientific beliefs too rigidly, even when they were actually wrong,

- There are records of a number of professional disagreements progressing to lifelong emnity, and he was sometimes intolerant and brutally direct in his critique of those with opposing points of view

- **Baldasarre Capra** – Plagiarised Galileo’s Military Compass and tried to claim it as his own – Galileo’s rebuttal was justified but was quite disproportionate and even made animal references etc.

- **Christoph Scheiner**, the Jesuit Priest from ‘Letters on Sunspots’ – Protracted, bitter and lifelong argument between Scheiner and Galileo,

- **Orazio Grassi**, another Jesuit Priest – in 1618 Grassi argued that comets were celestial bodies located beyond the Moon, but then went on to argue this as a proof of the Aristotlean Universe. Galileo speculated whether comets could have been optical illusions in the atmosphere, and in his book, ‘The Assayer’ was very scornful of Grassi.

- Ironically, the Jesuits had originally been strong allies of Galileo, but in the long term he **managed to alienate them**, which may have contributed to him falling foul of the Vatican

Pope Paul V

Controversy with the Vatican

- During the writing of the Letters on Sunspots, Galileo had become bolder in his support for Copernican theory. Some religious figures took took offence.
- We do know that Galileo wrote to Kepler as far back 1597 confirming his belief in Copernicism
- Galileo had over many years, made a number of enemies with some of his outspoken opinions. Had published occasional critical letters in regards to his strong points of view… see the next slide
- There were several complaints to the Church and to the Pope.
- In February 1616, Pope Paul V instructed Cardinal Bellarmine to meet with Galileo
- Galileo was instructed by the Cardinal and the Catholic Church to **abandon any teachings or support of the Copernican model.**

The Assayer(Il Saggiatore)

- Dedicated to Maffeo Barberini (future Pope Urban VIII),
- Was critical and insulting to both the Jesuit Astronomers Christoph Scheiner and Orazio Grassi,
- Was well received by Barberini/Future Pope Urban VIII
- Not very well received by the Jesuits

1623 Maffeo Barberini becomes Pope-Urban VIII

- Barberini/Pope Urban had been one of Galileo's long-standing supporters and Patrons,

- Possibly this made him feel that he would be able to write about Copernicism…

1632 - A Dialogue Concerning Two Chief World Systems

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.

Some details about ‘A Dialogue’

- Dedicated to the Medici Family
- Concerned with Copernicism v’s Ptolemiac/Aristolean motion
- Manuscript sent for prior Approval with the Inquisition,
- Originally titled “Dialogue on Ebb and Flow of the Sea”, but was ordered to be changed by the Inquisition, otherwise, given the ‘green light’ for publishing.
- Covered a four day conversation between three characters, with two each believing their opposing view of the universe, and a neutral third party who they tried to convince.
- The proponent for the Ptolemaic system was named Simplicio, and subsequently was interpreted as a form of ridicule – possibly not a good idea...
- Tycho Brahe’s proposed alternative geo-centric model was not considered- it does explain a lot of the motion that we see,
- Galileo did maintain that the conclusion remained neutral and gave equal weight to each point of view.

Part 3 – 1633 - Inquisition

1633-Galileo summoned to Rome

- Several months after publication of ‘A Diaogue’, Galileo was summoned to stand before the Roman Inquisition,
- It has been suggested that Pope Urban VIII was very involved in Court intrigue in the Vatican and had to end Galileo’s patronage and also had to be seen as not ‘going soft’ on dissent,
- He was formally charged with heresy,
- He was formally questioned and torture was (according to some sources) considered,
- A tribunal of three clerics read his book and presented their finding,
- Note that the last execution for Heresy had taken place only 33 years prior.

The punishment for Heresy…

- Burning at the Stake for heresy had last occurred in Rome in 1600. (Giordiano Bruno, a Dominican Friar) – only 33 years earlier

Motivations for Galileo's arrest and trial

- Nowadays presented as a battle of Science v's Religious Dogma/Good v's Evil fight, with Galileo as the hero of Science and Reason,

- Maybe a lot more nuanced than that…

- The Pope may have been offended that the Character arguing for the Catholic Church in 'Dialogue' was named Simplico – can be interpreted as 'Simpleton' - this would seem unlikely,

- The Vatican may have felt that Galileo had tricked them into approving his new book without Galileo revealing to the Church it's bias towards a Copernican Universe. Allegedly he had been asked to talk about the **concept of Copernicus's theory** only.

- There may have been some lobbying from the Jesuits for Papal scrutiny of his work as a result of Galileo's previous acrimonious discourse with some of his Jesuit critics as (as previously noted),

- A recently discovered manuscript of his biography written by Thomas Salusbury in 1662 in England advances the theory that the Pope was angry with the Tuscan Duke of Medici for refusing to provide Military help to Pope Urban VIII during the 30 Years War, and arrested the Duke's friend Galileo in retribution -?? Plausible?

Galileo Facing the Inquisition, Christo Banti (1857)

A Modern Romantic view

Verdict of the inquisition

- Galileo convicted of three counts of Heresy
- Had to ‘abdure, curse and detest’ his belief in Copernicism
- Popular culture claims that after declaring that the Earth did not move, that he muttered to himself (and yet it moves, or ‘eppur si muove’), but no evidence of this, and why would he after being threatened with torture?,
- Also in popular culture, he apologises to the Pope on bended knee – again no evidence of this ever happening,
- Initially he was sentenced to jail, however he was 59, losing his sight and suffered from his chronic Rheumatoid illness, etc, some leniency prevailed
- The very next day, the sentence was commuted to house arrest,

Verdict of the inquisition (Cont'd)

- Various theories for his relatively civilised treatment and sentencing
- His past friendship with Pope Urban VIII back when he was Maffeo Barberini may have spared him severe treatment
- Some sources claim that the Medici Family also intervened on his behalf
- Initially he stayed with a supportive Archbishop in Siena,
- After some time, he was allowed to return home in the hills of Acreti and serve out his sentence at home.

Siena

Galileo’s final home in Acetri

Part 4 - Later years

- Galileo remained under House Arrest for the rest of his life,
- His publications were banned in Italy, and future publications were also banned,
- In theory, he was not meant to be doing any research, and he was kept under surveillance,
- However…
- He continued work on his final book in secret "*Discourses and Mathematical Demonstrations Relating to Two New Sciences"*
- He was offered publication in Venice, but in the end wisely chose to publish in the Netherlands
- His manuscript was smuggled out of his Apartment and published it in 1637 Leiden , Netherlands
- The Vatican became aware of it's publication but took no action.
- When it reached Rome, it quickly sold out.

Galileo's final work…

DISCORSI
E
DIMOSTRAZIONI
MATEMATICHE,
intorno à due nuoue ſcienze
Attenenti alla
MECANICA & I MOVIMENTI LOCALI,
del Signor
GALILEO GALILEI LINCEO,
Filoſofo e Matematico primario del Sereniſſimo
Grand Duca di Toſcana.
Con vna Appendice del centro di grauità d'alcuni Solidi.

IN LEIDA,
Appreſſo gli Elſevirii. M. D. C. XXXVIII.

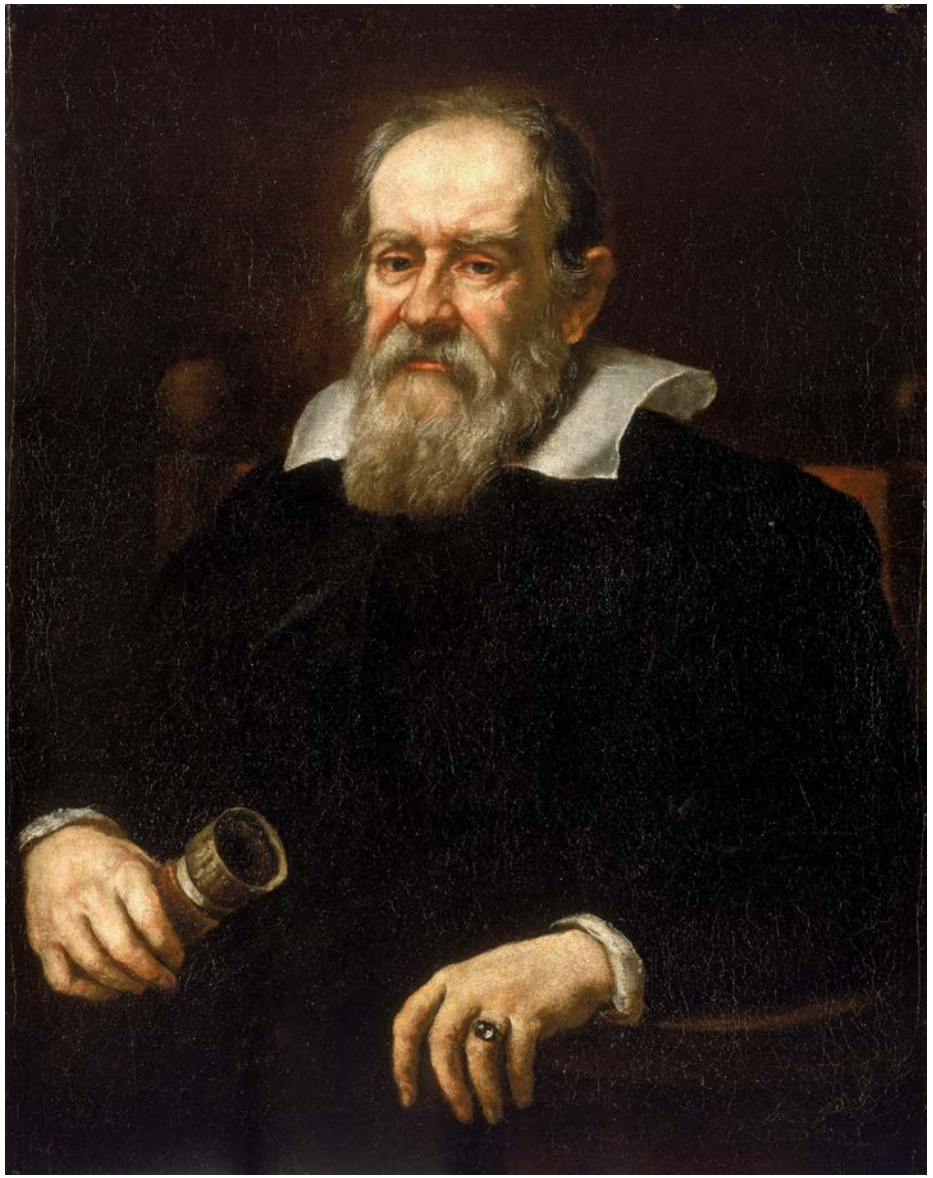
‘Discourses and Mathematical Demonstrations Relating to Two New Sciences’ - Reactions

- Took a similar format to his ‘Dialogue of Two Systems’ book of 1632
- Was seen as a ‘Landmark Publication’ of the time
- Considered the first book to deal with Classical Mechanics
- Is considered to have inspired Isaac Newton’s subsequent ‘Prinicpia’

- Two Modern Critiques of ‘Discourses’

- So great a contribution to physics was *Two New Sciences* that scholars have long maintained that the book anticipated Isaac Newton's laws of motion. – Stephen Hawking
- Galileo ... is the father of modern physics—indeed of modern science – Albert Einstein

Gaileo portrait 1640



Galileo – Passed away 1642

- The Grand Duke of Tuscany requested that he be buried with his Father in the main body of the Basilica Santa Croce in Florence and erect a Marble Mauseoleum in his honour,
- The Catholic Church opposed this,
- He was instead buried in a relatively obscure part of the Basiclica,
- In 1737, he was reburied in the Main Basilica in his originally intended place by his father,
- When reburied, three fingers and one tooth were removed,
- One finger is still on display in the Museo Galileo, Florence

Legacy

- Galileo's achievements are almost to many to mention. They include advances in :

- Establishing Scientific Method,
- Physics,
- Engineering,
- Mathematics

- But most of all, from our perspective he became the Father of Astronomy

Galileo’s Right middle finger

(Muselo Galileo, Florence)

Pope John Paul II

In 1992, the Pope apologised for the Catholic Church's treatment of Galileo

The End